VEGETATION MANAGEMENT ACTIVITIES OF FORESTRY CANADA

A Compendium of Summaries 1989–90

E.T. Oswald, Editor

Forestry Canada Forêts Canada

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VEGETATION MANAGEMENT ACTIVITIES OF FORESTRY CANADA

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Abstract

Forestry Canada has been involved with vegetation management for reforestation following logging for several years. Much of the initial work was centered around the use and registration of herbicides. Public concern about the use of chemicals has fostered an effort to find alternative vegetation control techniques. Several types of equipment have been used for site preparation across Canada, but further assessments are required on the impact much of the equipment has on the site. The primary objective of site preparation is to enhance the establishment and growth of the next crop of trees. The use of improved planting stock and techniques can alleviate some aspects of site preparation on some sites. Prescribed fire has several attributes suitable for site preparation, but due to environmental concerns such as smoke emission and nutrient loss, should be used only where other techniques are not available.

Summaries of past and present research in vegetation management conducted by Forestry Canada are presented. Most studies are still in progress, thus few conclusions are given. The summaries are arranged alphabetically by senior author within each Forestry Canada region beginning with eastern Canada and progressing to the west coast. The final chapter attempts to summarize the work being done, and presents a table to assist in locating personnel working on specific aspects of vegetation management. The appendices provide addresses to contact Forestry Canada personnel if more information is desired about a study. We also encourage personnel of other agencies working on vegetation management to cooperate with the ongoing task of keeping abreast of what is being done in the field by submitting summaries of their work for inclusion in our data base.

Résumé

Forêts Canada participe depuis plusieurs années à la gestion des végétaux relative au reboisement suite à la coupe. La majeure partie des premiers travaux concernait l'utilisation et l'homologation des herbicides. Les inquiétudes du public suscitées par le recours aux herbicides ont incité à rechercher d'autres techniques de lutte contre la végétation. Quoique plusieurs types d'équipements aient été employés au Canada pour la préparation des sites, il est nécessaire de procéder à des évaluations plus approfondies des incidences qu'ont nombre d'entre eux sur le site. Le premier objectif de la préparation du site est de favoriser l'implantation et la croissance du peuplement d'arbres suivant. Le recours à un matériel de reproduction et à des techniques améliorés peut alléger certains aspects de la préparation du site à certains endroits. Le brûlage dirigé possède plusieurs caractéristiques le rendant approprié à la préparation du site; toutefois, compte tenu des problèmes environnementaux tels que l'émission de fumées et la perte des substances nutritives, ce procédé ne devrait être qu'une solution de dernier recours.

Nous présentons dans le présent recueil les résumés des travaux de recherche passés et présents en gestion des végétaux menés par Forêts Canada. La plupart des études étant encore en cours, on y trouvera peu de conclusions. Les résumés sont présentés par ordre alphabétique en fonction du nom de l'auteur principal au sein de chaque région de Forêts Canada, à commencer par l'est du Canada jusqu'à la côte ouest. On trouvera dans le dernier chapitre une tentative de résumé des travaux, ainsi qu'un tableau destiné à faciliter la localisation des chercheurs travaillant sur des aspects spécifiques de la gestion des végétaux. Les annexes indiquent les adresses des membres du personnel de Forêts Canada devant être contactés pour obtenir des renseignements plus détaillés sur une étude donnée. Nous encourageons les chercheurs des autres organismes dans le domaine de la gestion des végétaux à contribuer à la mise à jour constante des recherches menées dans ce secteur en soumettant des résumés de leurs travaux pour fins d'intégration à notre base de données.

Chapter 1. Introduction

TheVegetation Management Working Group of Forestry Canada was formally approved by the Committee of Research Establishments in the spring of 1987. The working group consists of at least one appointed member from each regional establishment and national institute, and a secretary from headquarters. It is expected that meetings will be held annually, or at such other times as may be warranted, and will be held in various parts of the country to facilitate appreciation of the forest vegetation management concerns as they differ in each region.

The mandate of the working group shall be to promote sound methods of forest vegetation management in Canada. This will be accomplished by:

(i) defining vegetation management concerns on a regional basis and describing those with a national scope;

(ii) developing vegetation management guidelines and solutions to forest vegetation management problems;

(iii) developing and maintaining a working rapport with scientists in vegetation management-related research in Forestry Canada, and regional agencies in the fields of biocontrol, prescribed burning, herbicide application, planting stock production, scarification techniques; and

(iv) advising Forestry Canada's management on vegetation management priorities and responding to policy and planning guidelines.

This working group has a broad field of endeavor and the members recognize the need to interact with other groups concerned with various aspects of reforestation silviculture. The working group will actively promote the coordination of research among Forestry Canada establishments and provide advice to its research managers. The group will have a supportive role in Forestry Canada in the areas of development and coordination of vegetation management programs. Interactions within the peer review system and the ongoing program assessment are to be expected.

Current working group members by regional establishment are (see Appendix D for office addresses):

Newfoundland and Labrador Region — Brian Titus
Maritimes Region — Len Lanteigne
Quebec Region — Claude Delisle
Forest Pest Management Institute — Phil Reynolds
Ontario Region — Roy Sutton, Jim Wood, Fred von Althen
Northwest Region — Lorne Brace, Joe Feng, Surin Sidhu
Pacific and Yukon Region — Ed Oswald (Chairperson)
Forestry Canada, Headquarters — J. Peter Hall (Secretary)

At the inaugural meeting of the working group held in Sault Ste. Marie in May 1988, it was decided that an overview of vegetation management work being done within Forestry Canada would be beneficial to gain an appreciation of our current status, to identify data gaps, and to formulate proposals for strengthening Forestry Canada's role in vegetation management. Summaries were prepared by each study leader according to an agreed format, scientifically edited by the regional working group member, sent to the chairman for editing and compiling, and then forwarded to the working group secretary for printing. The ensuing document titled "Vegetation Management Activities of Forestry Canada: A Compendium of Summaries, 1988/89" received limited distribution, but the response to it warranted a more formal report. Thus some of the summaries were updated, others were added, some were revised, and several appendices were added in this information report to enhance the summaries. It is expected that the summaries will eventually be put on a computer data base for updating and to facilitate accessibility. We hope to expand the data base to include the work of other agencies in the ensuing years; therefore, we have included guidelines for the submission of summaries (Appendix E) for the use of those who would like to have their vegetaton management summaries included in the data base and in any future publications We encourage the use of these guidelines by all Canadian agencies working in vegetation management.

The last chapter includes a summary index by authors and method of vegetation control used that will facilitate locating particular items of interest. Appendix A is a list of common and scientific plant names for cross reference purposes. Where possible, common names are used in the summaries, and the plants in Appendix A are listed alphabetically by common name within the major plant groups. Suitable common names do not exist for some of the fungi and bacteria, thus the scientific names were used in the summary without cross reference. A list of publications pertaining to vegetation management by Forestry Canada personnel is presented in Appendix B. These are cross referenced to the summaries where applicable for ease in locating additional information about a summary if such is available. Appendix C is an alphabetical list of authors and their current place of employment, which may differ from the Forestry Canada regional establishment indicated in the chapters; the Forestry Canada office addresses are listed in Appendix D for those wishing additional information about any of the summaries. The format and procedure for submitting summaries to the data base by agencies other than Forestry Canada are given in Appendix E.

Outline of Summaries

The summaries are grouped in chapters according to the Forestry Canada regional office at which the research was conducted, and alphabetically by the senior author within a chapter. This arrangement should facilitate locating the work of a particular scientist by cross reference with Appendices C and D. The dates the study was initiated and completed follow the title, or a "P" is used to indicate the study is still in progress. A single date indicates the study was completed within 1 year. Following the authors, the objective, location, methods, results, and conclusions are given as appropriate. The Forestry Canada regional office from which the work was performed is then listed. Generally this is the location of the senior author, but there are exceptions; for example, the senior author may have moved since the time of the work, or the senior author may be affiliated with an agency outside of Forestry Canada. If the study was published, a reference to the list of publications (Appendix B) is given at the end of the summary.

Chapter 2. Newfoundland and Labrador Region Summaries

RICHARDSON, J.; Titus, B.D. Control of hardwood competition and release of softwood regeneration on a mixedwood cutover in western Newfoundland. 1977-P. **Objective:** To compare chemical and mechanical brushcutting techniques for the release of softwood regeneration on a highly productive mixedwood cutover. **Location:** South Brook valley, 25 km east of Corner Brook, western Newfoundland. **Methods:** ***Site History*** — Original stand of balsam fir and white birch was harvested (clearcut) for pulpwood in 1969. The experiment was established in 1977 in the middle of a moderately steep, east facing slope, at which time the site had regenerated to balsam fir, white birch, and pin cherry, with a ground vegetation of raspberry and fireweed. ***Soils*** — Fresh to moist stony loam (sand 42%, silt 35%, clay 23%). In 1977 the pH of combined A and upper B horizons was 5.0, OM content was 12%, and total nutrient concentrations of N, P, and K were 2788, 710, and 6625 ppm. ***Application Specifications*** — Five treatments: 2,4,5-T + 2,4-D (Brushkill®, amine formulation, with a.i. at 1.4 kg/ha in each of the compounds (thus 2.8 kg a.i. in total), in water at 700 L/ha, applied July 5–6, 1978); triclopyr (Garlon® 3A, triethyl amine formulation, a.i. 1.9 kg/ha, in water at 700 L/ha, applied July 6–7, 1978); glyphosate (Roundup®, a.i. 2.25 kg/ha, in water at 400 L/ha, applied August 28–29, 1978); mechanical brushcutting with portable motorized brushcutters, applied August 24–25, 1978; and control. The three herbicides were applied with a motorized backpack mist blower. ***Experimental Design*** — Treatment plots (25 × 40 m) were randomized and replicated four times; 15 permanent vegetation quadrats (2 × 2 m) were established end-on-end along a randomly located transect in each plot. ***Measurements Taken*** — Softwood height and leader length, hardwood height, stem density, and ground vegetation were recorded in 1977 (pre-treatment), July 1979 (1 year post-treatment), August 1980 (2 years post-treatment), and 1984 (6 years post-treatment). **Results:** At 1 year post-treatment, glyphosate caused the only statistically significant reduction in hardwood stem density (70%), followed by 2,4,5-T + 2,4-D (60%) and triclopyr (26%), while brushcutting caused a statistically significant increase in stem density (245%). Two-year results were similar. Total, relative, and percentage softwood height and leader length increased with herbicide treatments, but the differences were not statistically significant. The lack of significance is attributed to pre-treatment variation in fir height. Six-year data are being analyzed at present, and future remeasurements are envisaged. **Conclusion:** Chemical treatments were successful in reducing hardwood competition, while brushcutting ultimately increased hardwood stem density over the first 2 years. No treatments resulted in significantly increased softwood height growth. **(Forestry Canada, Newfoundland and Labrador Region , St. John's, Newfoundland)** Publ. No. A-23, A-26

RICHARDSON, J.; Titus, B.D. Release of young spruce and pine from alder competition. 1975-P. **Objective:** To compare chemical and mechanical brushcutting techniques for the release of softwood regeneration overtopped by alders. **Location:** North Pond experimental area, 32 km south of Gander, Newfoundland. **Methods:** ***Site History*** — The original mature black spruce and balsam fir forest was burned in 1941 and 1961. The area was seeded by helicopter in 1965 with black spruce and jack pine, and in 1970 was 85% and 59% stocked to black spruce and jack pine at densities of 18 800 and 4 000 stems/hectare, respectively. Alders rapidly overtopped the softwoods. The experiment was laid out in the spring of 1975. ***Application Specifications*** — Five treatments: 2,4-D (applied July 8–9, 1975, a.i. acid equivalent of the amine formulation at 1.1 kg/ha, in water at 400 L/ha, using a backpack mist blower); 2,4-D at the same rate but applied August 6–7, 1975; picloram (Tordon® 10K with a.i. at 4 kg/ha as pellets, by hand); brushcutting in August–October 1975 using motorized brushcutters and axes; and control. ***Experimental Design*** — Treatment plots (50 × 40 m) were randomized in four replicates. Two subplots (10 × 10 m) were randomly located within each treatment plot, and subdivided into 25 permanent quadrats (2 × 2 m). ***Measurements Taken*** — Pre-treatment surveys were conducted in spring of 1975, and post-treatment surveys in May 1976, August 1976 (1-year), August–September 1977 (2-year), September 1979 (4-year), and September–November 1984 (9-year). **Results:** Two years after treatment, hardwood cover was significantly reduced with all treatments except early application of 2,4-D. No statistically significant effect occurred on softwood height or leader length 2 years after treatments and there was no significant effect on stocking or density of spruce and pine. Picloram had a noticeably negative effect on jack pine stocking and density. Brushcutting increased hardwood stem densities by 25%, and hardwood sprouting was least on picloram plots (only 27% of original density). At 4 years there were still no statistically significant treatment effects, but trends were apparent. Picloram had the largest negative influence on spruce and pine stocking and density; pines were especially sensitive to damage. The lack of treatment effect is attributed to large variations in pre-treatment conditions. Increased softwood growth was most pronounced where hardwoods were more than twice as tall as softwoods before treatment, suggesting that alders do not pose a serious threat unless competition is a major problem. Perhaps a trade-off between increased alder competition for growth-limiting resources and increased soil fertility through N-fixation may account for the reduction in alder competition yet lack of significant softwood response. Future studies on this site utilizing stem volume are envisaged. Also, an alder interplanting experiment on another site utilizing a range of alder densities has been initiated to investigate under more controlled conditions the interaction between alders and softwoods. **Conclusion:** Chemical methods were better at controlling hardwood growth than mechanical methods. There was no demonstrable increase in softwood growth, attributed to possible beneficial effects of alders on soil fertility. **(Forestry Canada, Newfoundland and Labrador Region, St. John's, Newfoundland)** Publ. No. A-24, A-25

TITUS, B.D.; Meades, W.; Roberts, B.A. Establishment of softwoods on sites dominated by sheep-laurel. 1987-P. **Objective:** To successfully establish softwoods (spruce, pine, or larch) on sites heavily dominated by sheep-laurel. **Location:** Northern Arm Brook valley, 6.5 km west of Botwood, central Newfoundland. **Methods:** ***Site History*** — The previous stand of 65–70-year-old black spruce was commercially thinned in 1973–74, burnt in a wildfire in 1979, and salvage-cut in 1982. The site is now heavily dominated by sheep-laurel, a species thought to allelopathically inhibit black spruce growth. ***Soils*** — Coarse, well drained, on a kame terrace. ***Experimental Design*** — A large trial was laid out in 1987 to test a combination of treatments to be applied over the next 2 years using a full factorial split plot design replicated four times.

Treatment	Number	Description	Date
Scarification	2	(control, TTS disc trencher)	1989
Herbicide	2	(control, triclopyr + hexazinone)	1989
Fertilizer	3	(control, NPK, FYTO-2H®*)	1990
Species	3	(black spruce, jack pine, European larch)	1990

*A fertilizer plus biological extract developed by Biofutura Oy Ltd., Finland.

There are a total of 2 × 2 × 3 × 3 = 36 treatments. Site preparation (scarification +/- herbicide +/- fertilizer) treatment plots are 30 × 30 m, with 5-m buffer strips separating plots. Each replicate was split and randomized for application of the disc trenching. The factorial herbicide and fertilizer treatments were then randomly assigned, as methods allow greater mobility for application of these two treatments. The 30 × 30 m site-preparation treatment plots were subdivided for the three species treatments (30 × 10 m each). In 1990, 150 seedlings will be planted in each treatment at a 1 × 2 m spacing, to allow for destructive sampling. Herbicides were applied in the summer of 1989 as follows: hexazinone (Velpar® L) at 18 L/ha (a.i. 4.32 kg/ha) in June and triclopyr (Garlon® 4) at 8 L/ha (a.i. 3.84 kg/ha) in mid-July. Observations in the fall of 1989 suggest that the double application was very effective in killing sheep-laurel. Scarification took place in October 1989. ***Planned Measurements*** — Seedling response (height, root collar diameter, biomass, nutrient content, and concentration) will be measured after one, two, three, and five growing seasons. Sheep-laurel response will be determined from permanent plots. Organic matter will be sampled for nutrient capital and availability, and field decomposition rate. **Results:** Initial silvicultural prescription recommendations will be made at the end of 3 years, and these will be updated at the end of 5 years. **Additional Comments:** The field trial is a cooperative venture among all forestry agencies in the province. All treatments are ones that are or could be made operationally viable in Newfoundland, except for the herbicide treatment, where the aim is to ensure that sheep-laurel is killed rather than merely "knocked back." If this treatment is successful, specifically designed herbicide field trials will have to follow. Initial observations from operational sprays suggest that glyphosate (Vision®) may be effective in partially or totally killing sheep-laurel, and it is envisaged that an experimental design incorporating dosage × surfactant × time of application treatments over a range of sites of varying productivity will ultimately be appropriate. **(Forestry Canada, Newfoundland and Labrador Region, Abitibi-Price, and Corner Brook Pulp and Paper Ltd., St. John's, Newfoundland)** Publ. No. D-7

Chapter 3. Maritimes Region Summaries

LANTEIGNE, L.J. The impact of cleaning with herbicide on successional development and the growth of balsam fir after clearcutting a fir–spruce forest. 1984. (M.Sc.F Thesis, University of New Brunswick). **Objectives:** To determine the effects of clearcutting and subsequent cleaning with herbicide on community structure and functional processes, to determine the growth response of balsam fir to cleaning with herbicide. **Location:** Maritime uplands ecoregion, New Brunswick. **Methods:** ***Site History*** — Mixedwood stand, harvested in 1962. Clearcutting resulted in abundant regeneration, particularly of pioneer species, such as pin cherry and red raspberry. ***Soils*** — Surficial deposits of glacial basal till and minor ablation till, resulting in fertile stony loams and silt loams with a depth of 0.5 m and a Ferro-Humic Podzol development. ***Application Specifications*** — In July 1974, a low volatile ester of Brushkill® 76 (2,4-D and 2,4,5-T mixture) was applied aerially at an ingredient rate of 9.3 L/ha in water. ***Experimental Design*** — In 1983, 1-ha blocks were established with perpendicular transect lines, and 25 intersection points were randomly selected for midpoints of sample plots. ***Measurements Taken*** — Annual height increments, age determination, diameter, basal area, and volume growth. **Results:** Cleaning with herbicide resulted in an immediate and significant growth increase by the suppressed understory balsam fir, with no shock effect or lag time in growth response. Cleaning increased height growth by 9–34%, diameter growth by 28–46%, basal area growth by 49–120%, and volume growth by 142–257%. However, there was a rapid shift from interspecies competition to intraspecies competition amongst balsam fir stems, due to extremely high density. Specific volume increment displayed great sensitivity to this density-dependent relationship of intraspecies competition. **Conclusion:** The ability of balsam fir to maintain population levels beneath the dense hardwood canopy, the immediate growth response to release, the short life-span of pin cherry, and the maintenance of subordinate plant species diversity indicate that herbicide treatment does not alter the direction of community development after disturbance, but rather the rate of this development. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. A-18

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effects of pre-emergence herbicides on weed control and the growth of r1 + 0 black spruce and jack pine seedlings. 1985. (Expert Committee on Weeds – Eastern Section) **Objectives:** To study the effect of various pre-emergence herbicides on grass and broadleaf weeds and on germination and growth of r1 + 0 black spruce and jack pine seedlings. **Location:** J.D. Irving's Forest Nursery, Juniper, New Brunswick **Methods:** ***Growth Medium*** — Bareroot seedbed of well-drained loamy sand . ***Application Specifications*** — A Research and Development sprayer equipped with pressurized CO_2 and LP8003 nozzles was used. Total spray volume was 236 L/ha at 207 kPa. Treatments were applied before germination of both weeds and conifer seedlings. ***Experimental Design*** — Randomized block with three replications. Treatment plots were 1.3 m wide by 3 m long. ***Measurements Taken*** — Weeds were classified as grass or broadleaf, counted, and removed from the plots twice during the growing season. Height, root collar diameter, and dry weight were measured for 30 seedlings randomly selected from each treatment **Results:** The only treatments that significantly affected germination were napropamide (increase is +40%) and propazine (decrease is – 15%) for black spruce. There was no significant effect on jack pine germination. There was no significant herbicide effect on seedling growth of black spruce or jack pine at the completion of one growing season.

Herbicide a.i. (kg/ha)	Percent control	
	Grass	Broadleaf
Bifenox (1.12)	82	65
Oxyfluorfen (0.28)	94	76
Prometryn (1.12)	72	77
Napropamide (2.24)	95	58
Propazine (1.12)	92	95
DCPA (6.72)	44	10
Napropamide + oxyfluorfen	100	92
Prometryn + DCPA	86	81
Control	–	–

Conclusions: Propazine (a.i. 1.12 kg/ha) may significantly reduce germination of black spruce. Use of DCPA (a.i. 6.72 kg/ha) does not provide satisfactory control of grass and broadleaf weeds **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-7

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effects of sethoxydim, fluazifop-butyl, and oxyfluorfen on weed control and black spruce container seedlings. 1985 (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of sethoxydim, fluazifop butyl, and oxyfluorfen on major weed species and on black spruce seedlings **Location:** Department of Natural Resources' Forest Nursery, Kingsclear, New Brunswick **Methods:** ***Site History*** — Black spruce was seeded in May 1985 in multipots containing a growing medium of spaghnum peat moss and vermiculite. The seedlings were grown in an open holding area Before herbicide testing, 12 weed species were present with a 30–39% cover. The major weed species were aspen poplar and rush and grass species. ***Application Specifications*** — A Research and Development sprayer equipped with pressurized CO_2 and LP8003 nozzles was used Total spray volume was 486 L/ha at 207 kPa The following herbicides and rates were applied on July 30, 1985: sethoxydim, fluazifop-butyl, and oxyfluorfen with a.i. at 0.28, 0.56, and 1.12 kg/ha. There was no rainfall during application or within 48 hours following application. ***Experimental Design*** — Split-plot randomized block design with five replications. ***Measurements Taken*** — Qualitative evaluation of both weed control and seedling damage was conducted. **Results:** There was slight needle burn to the uppermost needles of the black spruce seedlings from oxyfluorfen at a.i. of 1.12 kg/ha. The apical meristem was not damaged and seedlings recovered rapidly. Oxyfluorfen provided 50–79% control of aspen poplar with no significant relationship between rate and control. Sethoxydim and fluazifop-butyl had no effect on rush Oxyfluorfen provided 60–100% control of rush, with a direct relationship between rate and control Sethoxydim and fluazifop-butyl provided 20–79% control of grass, with a direct relationship between rate and control. **Conclusions:** Operational rates of oxyfluorfen (a.i. at < 0.56 kg/ha) can provide satisfactory control of aspen poplar and rush species without severe damage to black spruce seedlings. Sethoxydim and fluazifop-butyl at a.i. of 1.12 kg/ha will provide satisfactory control of grass species without damage to black spruce seedlings. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No C-8

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effects of various pre-emergence herbicides on germination and growth of jack pine seedlings within a bareroot seedbed. 1986 (Expert Committee on Weeds - Eastern Section) **Objectives:** To study the effect of various pre-emergence herbicides on germination and growth of jack pine bareroot seedlings **Location:** J.D. Irving's Forest Nursery, Juniper, New Brunswick. **Methods:** ***Site History*** — Seedbed was prepared in the fall of 1983. Seeding density was 68 seeds per 0.1 m^2 with an objective of 25 seedlings per 0.1 m^2 at r2 + 0 Seedlings were not germinated at time of herbicide application ***Soils*** — Loamy sand ***Application Specifications*** — Treatments were applied on June 4, 1984, with a Research and Development sprayer equipped with pressurized CO_2 and LP8003 nozzles. Total spray volume was 486 L/ha at 138 kPa ***Experimental Design*** — Stratified random block with three replications. Three subplots were located within each treatment plot to determine seedling density. ***Measurements Taken*** — Seedling counts were conducted in July and August 1984. Height, root collar diameter, and dry weight for 30 randomly selected seedlings from each treatment were taken in fall 1984 (r1 + 0) and fall 1985 (r2 + 0). Data for height and root collar diameter were subjected to variance analysis and means were separated using Duncan's multiple-range test ($P = 0.05$). Data for dry weight were subjected to non-parametric statistics (linear ranking) and variance analysis was performed on ranked score ($P = 0.05$). **Results:**

			r1 + 0		r2 + 0	
Treatment	Rate of a.i. (kg/ha)	No. seedlings per 0.1 m^2	Height (cm)	Dry weight (g)	Height (cm)	Dry weight (g)
Bifenox	1.12	42	5.7	0.48	21.0	2.84
Oxyfluorfen	0.28	42	5.4	0.47	22.1	2.79
Prometryn	1.12	42	5.0	0.44	19.5*	2.20*
Napropamide	2.24	41	5.1	0.37	20.8	3.43
Propazine	1.12	41	5.0	0.38	18.9*	2.72
DCPA	6.72	49	5.4	0.44	20.0	2.66
Napropamid/ oxyfluorfen	2.24/ 0.28	48	5.0	0.41	20.4	2.58
Prometryn/ DCPA	1.12/ 6.72	43	5.0	0.40	19.9*	2.45*
Control		50	5.5	0.48	22.7	3.82

*Significantly different from control ($P = 0.05$).

Conclusions: All the herbicide treatments decreased jack pine germination but the decrease was not significant. Propazine and prometryn can cause a significant decrease in growth (r2 + 0) of jack pine seedlings. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-9

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effects of various pre-emergence herbicides on germination and growth of black spruce seedlings within a bareroot seedbed. 1986. (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of various pre-emergence herbicides on germination and growth of black spruce bareroot seedlings **Location:** J.D Irving's Forest Nursery, Juniper, New Brunswick. **Methods:** ***Site History*** — Seedbed was prepared in the fall of 1983. Seeding density was 460 seeds per 0.1 m^2, with an objective of 125 seedlings per 0.1 m^2 at r2+0. The seeds had not germinated at time of herbicide application. ***Soils*** — Loamy sand ***Application Specifications*** — Treatments were applied on June 4, 1984, with a Research and Development sprayer equipped with pressurized CO_2 and LP8003 nozzles. Total spray volume was 486 L/ha at 138 kPa. ***Experimental Design*** — Stratified random block with three replications. Three subplots were located within each treatment plot to determine seedling density ***Measurements Taken*** — Seedling counts were conducted in July and August 1984. Height, root collar diameter, and dry weight for 30 randomly selected seedlings from each treatment were taken in fall 1984 (r1 + 0) and fall 1985 (r2+0). Data for height and root collar diameter were subjected to variance analysis and means were separated using Duncan's multiple-range test ($P = 0.05$). Data for dry weight were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked score ($P = 0.05$). **Results:**

			r1 + 0		r2 + 0	
Treatment	Rate of a.i. (kg/ha)	No. seedlings per 0.1 m^2	Height (cm)	Dry weight (g)	Height (cm)	Dry weight (g)
Bifenox	1.12	145	3.3	0.08	17.3	0.66
Oxyfluorfen	0.28	162	3.6	0.07	16.2	0.62
Prometryn	1.12	140	3.3	0.06	15.2*	0.54*
Napropamide	2.24	186*	3.2	0.07	17.0	0.63
Propazine	1.12	114	3.1	0.06	14.3*	0.69
DCPA	6.72	142	3.5	0.07	15.6	0.64
Napropamide/ oxyfluorfen	2.24/ 0.28	163	3.7	0.08	16.3	0.66
Prometryn/ DCPA	1.12/ 6.72	154	3.2	0.07	16.6	0.67
Control	–	133	3.6	0.08	17.4	0.65

***Significantly different from control ($P = 0.05$).**

Conclusions: Napropamide can result in a significant increase in black spruce germination. Propazine and prometryn can result in decreased seedling growth of black spruce during both the first (r1+0) and second (r2+0) growing seasons. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-10

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effect of sethoxydim, fluazifop-butyl, and oxyfluorfen on control of rye grass. 1986. (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of total spray volume, additives, and tank mixes of sethoxydim, fluazifop-butyl, and oxyfluorfen on rye grass. **Location:** Department of Natural Resources' Forest Nursery, Kingsclear, New Brunswick. **Methods:** ***Site History*** — Rye grass was seeded as a fallow crop in fall 1985. Treatments were applied on May 6, 1986, when the rye grass was at the 3–5 leaf stage, and 5–10 cm in height. ***Soils*** - Sandy loam. ***Application Specifications*** — A Research and Development sprayer equipped with pressurized CO_2 was used. Herbicides tested were sethoxydim, fluazifop-butyl, and oxyfluorfen at a.i. of 0.5 kg/ha. Total spray volumes were 121 L/ha (L80015 nozzles at 140 kPa), 243 L/ha (LP8003 nozzles at 140 kPa), and 486 L/ha (LP8003 nozzles at 140 kPa). There was no rainfall within 48 hours following treatment application. ***Experimental Design*** — Randomized block. ***Measurements Taken*** — Qualitative visual estimates of treatment effect. **Results:** There was no difference between the three spray volumes and the control of rye grass for either sethoxydim or fluazifop-butyl. The addition of assist oil (1.5% of total spray volume) to sethoxydim and Agral 90 (0.1% of total spray volume) to fluazifop-butyl slightly increased herbicidal effect. The addition of oxyfluorfen in a tank mix with sethoxydim or with fluazifop-butyl decreased the herbicidal effect. Oxyfluorfen caused necrosis of the leaves, thereby decreasing translocation of sethoxydim or fluazifop-butyl to the roots for complete control of the plant. **Conclusion:** Application of sethoxydim and fluazifop-butyl resulted in similar control of rye grass, regardless of total spray volume. Addition of adjuvants increased control effectiveness; addition of oxyfluorfen decreased control effectiveness. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-11

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effect of napropamide and oxyfluorfen on the growth of black spruce bareroot seedlings. 1986. (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of napropamide and oxyfluorfen on the growth of black spruce bareroot seedlings. **Location:** J.D. Irving's Forest Nursery, Juniper, New Brunswick. **Methods:** ***Site History*** — Seed bed was prepared in fall 1982. Seedlings grew in the seedbed during 1983 and 1984. Seedlings were transplanted in spring 1985. Treatments were applied July 1985 when the seedlings were actively growing. ***Soils*** — Loamy sand. ***Application Specifications*** — Treatments were applied with a Research and Development sprayer equipped with pressurized CO_2 and LP8003 nozzles. Total spray volume was 486 L/ha at 138 kPa. ***Experimental Design*** — Randomized block with five replications. Sample plots were 1.3 m in width and 3 m in length. ***Measurements Taken*** — Height, root collar diameter, and dry weight were recorded for 50 randomly selected seedlings per treatment. Data were subjected to variance analysis and, where differences were indicated, means were separated by Student-Newman-Keul's multiple range test ($P = 0.05$). **Results:** There was no significant difference between treatments for height, root collar diameter, and dry weight. **Conclusion:** Napropamide and oxyfluorfen, applied over actively growing black spruce (r2 + 1) seedlings, will not significantly reduce growth. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-12

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effect of various pre-emergence herbicides on grass and broadleaf weeds. 1986. (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of bifenox, oxyfluorfen, prometryn, napropamide, propazine, and DCPA on grass and broadleaf weeds. **Location:** J.D. Irving's Forest Nursery, Juniper, New Brunswick. **Methods:** ***Site History*** — Seedbeds were prepared in fall 1983. Herbicides were applied June 4, 1984, before emergence of weeds. ***Soils*** — Loamy sand. ***Application Specifications*** — A Research and Development sprayer equipped with pressurized CO_2 and LP8003 nozzles was used. Total spray volume was 486 L/ha at 138 kPa. There was no rainfall within 48 hours following treatment application. ***Experimental Design*** — Stratified random block with three replications on two sites. ***Measurements Taken*** — Grass and broadleaf weeds were counted and removed from the treatment plots periodically during the growing season. Data were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked scores ($P = 0.05$). **Results:**

Treatment	Rate of a.i. (kg/ha)	Percent control	
		Grass	Broadleaf
Bifenox	1.12	82	65
Oxyfluorfen	0.28	94	76
Prometryn	1.12	72	77
Napropamide	2.24	95	58*
Propazine	1.12	92	95
DCPA	6.72	44*	10*
Napropamide/oxyfluorfen	2.24/0.28	100	92
Prometryn/DCPA	1.12/6.72	86	81

*Significantly different from control ($P = 0.05$).

Conclusions: All herbicides tested, except for DCPA, provided satisfactory control of grass and broadleaf species. Oxyfluorfen, napropamide, and propazine provided the best grass control. Propazine and napropamide + oxyfluorfen provided the best broadleaf control. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-13

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effect of oxyfluorfen, napropamide, DCPA, and prometryn on germination and growth of white spruce bareroot seedlings and on weed control. 1986. (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of oxyfluorfen, napropamide, DCPA, and prometryn on germination and growth of white spruce bareroot seedlings and on grass and broadleaf weeds. **Location:** J.D. Irving's Forest Nursery, Juniper, New Brunswick. **Methods:** ***Site History*** — Seedbeds were prepared in fall 1984. Treatments were applied November 1984 and a second application (booster) was made August 14, 1985, when the seedling roots were 6–8 cm in length. ***Soils*** — Loamy sand. ***Application Specifications*** — A Research and Development sprayer equipped with pressurized CO_2 and LP8003 nozzles was used. Total spray volume was 355 L/ha at 200 kPa. ***Experimental Design*** — Randomized block with three replications. ***Measurements Taken*** — Height, root collar diameter, and dry weight for 30 randomly selected seedlings per treatment were recorded at the end of the growing season. Germination counts were based on three 0.1-m^2 subplots with each treatment plot. Data were subjected to variance analysis and means were separated using Student–Newman–Keuls multiple-range test ($P = 0.05$). **Results:** None of the herbicide treatments had significant effect on germination, height, root collar diameter, or dry weight.

Treatment	Rate of a.i. (kg/ha)	Percent control	
		Grass	Broadleaf
Control	6.72	-	-
DCPA	6.72	0	12
DCPA	2.24	0	0
Napropamide	2.24	100	67
Napropamide (booster)	2.24	100	54
Oxyfluorfen	0.28	100	62
Oxyfluorfen (booster)	0.28	100	58
Oxyfluorfen/DCPA	0.28/6.72	100	54
Oxyfluorfen/DCPA	0.28/6.72	100	67
Oxyfluorfen/napropamide	0.28/2.24	100	88
Oxyfl./napropamide (booster)	0.28/2.24	100	92
Oxyfluorfen/prometryn	0.28/1.12	96	62
Oxyfl./prometryn (booster)	0.28/1.12	100	92
Prometryn	1.12	53	67
Prometryn (booster)	1.12	79	67
Prometryn/DCPA	1.12/6.72	42	50
Prometryn/DCPA (booster)	1.12/6.72	40	71

Conclusions: DCPA, napropamide, oxyfluorfen, and prometryn are not detrimental to germination and growth of white spruce seedlings when applied prior to germination and over actively growing seedlings. DCPA and prometryn provided unsatisfactory grass control. Oxyfluorfen + napropamide and oxyfluorfen + prometryn provided the best broadleaf control. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-14

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effect of oxadiazon on the growth of black spruce container seedlings. 1987. (Expert Committee on Weeds - Eastern Section) **Objectives:** To study the tolerance of 5-month-old black spruce container seedlings to oxadiazon at a.i of 3 8 kg/ha **Location:** Department of Natural Resources' Forest Nursery, Kingsclear, New Brunswick. **Methods:** ***Site History*** — Black spruce was seeded in early July 1985 and grown in greenhouses. The seedlings developed buds in early November 1985 and were placed outdoors in late November 1985. ***Application Specifications*** — Oxadiazon (Ronstar, G 2%, May and Baker) at a.i. of 3 8 kg/ha was applied operationally with a motorized Gandy spreader. ***Experimental Design*** — Seven holding areas were included. Five replicates of paired treatments (control-oxadiazon) were randomly located within each holding area. ***Measurements Taken*** — In October 1986, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height (0.1 cm) and root collar diameter (0.01 mm) were measured. Data were subjected to a t-test ($P = 0.05$). Oven-dry weight (0.01 g) for tops and roots (five trees per replicate grouped) was recorded. Data were subjected to nonparametric statistics (linear ranking) and a t-test was performed on ranked scores ($P = 0.05$). **Results:** There was no significant reduction in height, root collar diameter, or dry weight which could be attributed to oxadiazon. **Conclusion:** Oxadiazon at a.i. of 3.8 kg/ha applied at dormancy did not affect growth of 5-month-old black spruce container seedlings. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-15

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effect of various herbicides on the growth of black spruce container seedlings. 1987 (Expert Committee on Weeds - Eastern Section). **Objective:** To study the effect of oxyfluorfen, napropamide, trifluralin, DCPA, oxadiazon, and glyphosate on the growth of 5-month-old black spruce seedlings. **Location:** Department of Natural Resources' Forest Nursery, Kingsclear, New Brunswick. **Methods:** ***Site History*** — Black spruce was seeded in early July 1985 and grown in greenhouses. The seedlings developed buds in early November 1985 and were placed outdoors in late November 1985. Seedlings were dormant at the time of herbicide application. ***Application Specifications*** — Herbicide treatment included oxyfluorfen, a.i. 0.25, 0.5, 1.0 kg/ha; napropamide, a.i. 2.2, 4.4 kg/ha; trifluralin, a.i. 1.4, 2.8 kg /ha; DCPA, a.i. 5.0, 10.0 kg/ha; oxadiazon, a.i. 1.1, 2.2 kg/ha; and glyphosate, a.i. 0.42, 0.84 kg/ha. Emulsifiable concentrate formulations were applied with a CO_2 pressurized sprayer fitted with LP8003 nozzles delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. Granular formulations were applied manually. ***Experimental Design*** — Randomized complete block with five replications. ***Measurements Taken*** — In October 1986, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height, root collar diameter, and dry weight were measured. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.05$). **Results:**

Treatment	Rate of a.i. (kg/ha)	Height* (cm)	Root collar diameter* (mm)	Dry weight* (g)	
				Top	Root
Control	—	21.7^{abc}	2.8^{a}	6.34^{a}	0.99^{a}
DCPA	5.0	22.6^{abc}	2.6^{a}	5.65^{a}	0.90^{a}
DCPA	10.0	23.5^{abc}	2.8^{a}	6.49^{a}	1.05^{a}
Glyphosate	0.42	21.3^{abc}	2.7^{a}	5.90^{a}	1.06^{a}
Glyphosate	0.84	18.8^{d}	2.9^{a}	6.66^{a}	1.10^{a}
Napropamide	2.2	24.6^{a}	2.6^{a}	6.66^{a}	0.91^{a}
Napropamide	4.4	23.9^{ab}	2.7^{a}	7.05^{a}	1.04^{a}
Oxadiazon	1.1	22.0^{abc}	2.5^{a}	5.65^{a}	0.85^{a}
Oxadiazon	2.2	22.7^{abc}	2.5^{a}	5.95^{a}	0.90^{a}
Oxyfluorfen	0.25	22.8^{abc}	2.5^{a}	5.49^{a}	0.85^{a}
Oxyfluorfen	0.5	22.9^{abc}	2.6^{a}	6.70^{a}	0.98^{a}
Oxyfluorfen	1.0	23.0^{abc}	2.7^{a}	5.81^{a}	0.91^{a}
Trifluralin	1.4	22.8^{abc}	2.8^{a}	6.23^{a}	1.06^{a}
Trifluralin	2.8	20.5^{cd}	2.7^{a}	5.90^{a}	1.11^{a}

***Means with similar superscript letters are not significantly different from each other ($P = 0.05$).**

Conclusions: The only treatment that resulted in significant decrease in growth was glyphosate, at a.i. of 0.84 kg/ha. Additional research is required on the effect of glyphosate on conifer seedlings grown in sphagnum peat moss. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-16

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Post-emergence applications of oxyfluorfen and sethoxydim on 12-week-old black spruce and white spruce container seedlings. 1987. (Expert Committee on Weeds – Eastern Section) **Objectives:** To study the effect of oxyfluorfen and sethoxydim on 12-week-old black spruce and white spruce container seedlings. **Location:** Fraser Forest Nursery, Edmundston, New Brunswick. **Methods:** ***Site History*** — Black spruce and white spruce were seeded April 25, 1986, and emerged May 9, 1986. Herbicides were applied 12 weeks post-emergence, when the seedlings were 3–5 cm in height and actively growing. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Application Specifications*** — Treatments were applied with a pressurized CO_2 sprayer equipped with LP8003 nozzles delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. No rainfall was recorded within 48 hours of treatment. ***Experimental Design*** — Randomized complete block with five replications. ***Measurements Taken*** — On October 6, 1987, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height (0.1 cm) and root collar diameter (0.1 mm) were measured. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.05$). Oven-dry weight for tops and roots (five trees per replicate grouped) was recorded. Data were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked scores ($P = 0.05$). **Results:** A qualitative evaluation of seedlings 1 week following herbicide application indicated that there was no damage on the white spruce seedlings treated with oxyfluorfen at a.i. rates of 0.25 and 0.5 kg/ha but there was slight to moderate needle burn at 1.0 kg/ha. There was no damage from the a.i. rate of 0.25 kg/ha on black spruce but there was slight needle burn at a.i. rate of 0.5 kg/ha and moderate damage at 1.0 kg/ha. The apical meristem of the seedlings was not damaged in either species and elongation continued within 2 weeks of herbicide application. Even though there was slight to moderate damage to the needles of both black spruce and white spruce seedlings from some of the herbicide treatments, there was no significant reduction in height, root collar diameter, or dry weight at the end of one growing season. The addition of assist oil concentrate (83% oil/17% surfactant) did not have a significant effect on seedling growth. Sethoxydim did not significantly reduce seedling growth. **Conclusion:** The 12-week-old black spruce and white spruce seedlings were tolerant of applications of oxyfluorfen at the a.i. rate of 0.25 kg/ha. There was slight needle burn at 0.5 and 1.0 kg/ha but this did not result in significant reduction in growth. The seedlings for both species were tolerant of sethoxydim at a.i. rates of 0.25, 0.5, and 1.0 kg/ha. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-17

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Post-emergence applications of oxyfluorfen and sethoxydim on 5-week-old black spruce container seedlings. 1987 (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of oxyfluorfen and sethoxydim on 5-week-old white spruce container seedlings. **Location:** Fraser Forest Nursery, Edmundston, New Brunswick. **Methods:** ***Site History*** — Black spruce was seeded June 19, 1986, and emerged July 3, 1986. Herbicides were applied 5 weeks post-emergence, when the seedlings were 1–2 cm in height and actively growing. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Application Specifications*** — Treatments were applied with a pressurized CO_2 sprayer equipped with LP8003 nozzles, delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. No rainfall was recorded within 48 hours of treatment. ***Experimental Design*** — Randomized complete block with five replications. ***Measurements Taken*** — On October 6, 1987, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height (0.1 cm) and root collar diameter (0.1 mm) were measured. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.05$). Oven-dry weight for tops and roots (five trees per replicate grouped) was recorded. Data were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked scores ($P = 0.05$). **Results:** A qualitative evaluation of seedlings 1 week following herbicide application indicated that the a.i. rate of 0.25 kg/ha resulted in slight damage to the uppermost needles. There was a noticeable increase in needle damage as the rate increased. The addition of assist oil resulted in increased damage.

Treatment*	Rate of a.i. (kg/ha)	Height** (cm)	Dry weight** (g)	
			Top	Root
Control (weeded)	-	5.5^{a}	0.23^{ab}	0.10^{a}
Oxyfluorfen	0.25	5.4^{a}	0.21^{ab}	0.08^{ab}
Oxyfluorfen + assist oil	0.25	4.8^{ab}	0.17^{bcd}	0.06^{bc}
Oxyfluorfen + sethoxydim + assist oil	0.25	5.6^{a}	0.26^{a}	0.12^{a}
Oxyfluorfen	0.5	5.0^{ab}	0.18^{abc}	0.07^{bc}
Oxyfluorfen + assist oil	0.5	5.0^{ab}	0.19^{abc}	0.08^{ab}
Oxyfluorfen + sethoxydim + assist oil	0.5	4.4^{bc}	0.15^{cd}	0.06^{bc}
Oxyfluorfen	1.0	4.2^{bc}	0.14^{cd}	0.05^{c}
Oxyfluorfen + assist oil	1.0	4.3^{bc}	0.13^{cd}	0.06^{c}
Oxyfluorfen + sethoxydim + assist oil	1.0	3.9^{c}	0.12^{d}	0.05^{c}

*Assist oil concentrate (83%/17% surfactant, BASF) was added at 1% of total spray volume.

**Means with similar superscript letters are not significantly different from each other ($P = 0.05$).

Conclusion: Although oxyfluorfen caused needle damage to black spruce seedlings, the apical meristem was not damaged and height growth resumed within 2 weeks of herbicide application. Significant reduction in growth of black spruce seedlings can occur when oxyfluorfen is applied at a.i. rates of 0.5 and 1.0 kg/ha on 5-week-old actively growing black spruce seedlings. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-18

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Post-emergence applications of oxyfluorfen and sethoxydim on 5-week-old white spruce container seedlings. 1987. (Expert Committee on Weeds – Eastern Section). **Objectives:** To study the effect of oxyfluorfen and sethoxydim on 5-week-old white spruce container seedlings. **Location:** Fraser Forest Nursery, Edmundston, New Brunswick. **Methods:** ***Site History*** — White spruce was seeded June 19, 1986, and emerged July 3, 1986. Herbicides were applied 5 weeks post-emergence, when the seedlings were 1–2 cm in height and actively growing. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Application Specifications*** — Treatments were applied with a pressurized CO_2 sprayer equipped with LP8003 nozzles, delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. No rainfall was recorded within 48 hours of treatment. ***Experimental Design*** — Randomized complete block with five replications. ***Measurements Taken*** — On October 6, 1987, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height (0.1 cm) and root collar diameter (0.1 mm) were measured. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.05$). Oven-dry weight for tops and roots (five trees per replicate grouped) was recorded. Data were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked scores ($P = 0.05$). **Results:** A qualitative evaluation of seedlings 1 week following herbicide application indicated that the a.i. rate of 0.25 kg/ha resulted in slight damage to the uppermost needles. There was a noticeable increase in needle damage as the rate increased. The addition of assist oil resulted in increased damage.

Treatment*	Rate of a.i. (kg/ha)	Height** (cm)	Dry weight** (g)	
			Top	Root
Control (weeded)	–	4.2^{a}	0.27^{a}	0.11^{a}
Oxyfluorfen	0.25	4.0^{ab}	0.21^{ab}	0.09^{ab}
Oxyfluorfen + assist oil	0.25	4.0^{ab}	0.20^{b}	0.07^{bc}
Oxyfluorfen + sethoxydim + assist oil	0.25	5.6^{a}	0.26^{a}	0.12^{a}
Oxyfluorfen	0.5	3.7^{bc}	0.18^{bc}	0.07^{bc}
Oxyfluorfen + assist oil	0.5	3.6^{bc}	0.16^{cd}	0.07^{cd}
Oxyfluorfen + sethoxydim + assist oil	0.5	3.4^{cd}	0.16^{d}	0.06^{de}
Oxyfluorfen	1.0	3.4^{cd}	0.15^{d}	0.06^{de}
Oxyfluorfen + assist oil	1.0	3.5^{cd}	0.14^{d}	0.05^{e}
Oxyfluorfen + sethoxydim + assist oil	1.0	3.1^{d}	0.13^{d}	0.05^{e}

*Assist oil concentrate (83%/17% surfactant, BASF) was added at 1% of total spray volume.

**Means with similar superscript letters are not significantly different from each other ($P = 0.05$).

Conclusions: Although oxyfluorfen did cause needle damage to white spruce seedlings, the apical meristem was not damaged and height growth resumed within 2 weeks of herbicide application. Significant reduction in growth of white spruce seedlings can occur when oxyfluorfen is applied at a.i. rates of 0.5 and 1.0 kg/ha over 5-week-old actively growing seedlings. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-19

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. Effect of oxyfluorfen and lentagran on the growth of 4-week-old jack pine container seedlings. 1987. (Expert Committee on Weeds - Eastern Section). **Objectives:** To study the effect of oxyfluorfen and lentagran on the growth of 4-week-old jack pine container seedlings. **Location:** Department of Natural Resources' Forest Nursery, Kingsclear, New Brunswick. **Methods:** ***Site History*** — Jack pine was seeded in containers on July 2, 1986, and emerged July 11, 1986. The herbicide treatments were applied on August 7, 1986, 4 weeks post-emergence. The seedlings were 2–4 cm tall with good needle development and color. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Application Specifications*** — Herbicides were applied with a CO_2 regulated sprayer fitted with three LP8003 nozzles delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. ***Experimental Design*** — Randomized block design with five replications. ***Measurements Taken*** — In October 1986, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height (0.1 cm) and root collar diameter (0.1 mm) were measured. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.05$). Oven-dry weight for tops and roots (five trees per replicate grouped) was recorded. Data were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked scores ($P = 0.05$). **Results:** Within 1 week of herbicide application it was observed that oxyfluorfen resulted in needle burn to the youngest foliage with a direct relationship between amount of damage and rate of application. The 1.0-kg/ha a.i. rate resulted in about 25% damage to the uppermost needles. There was no damage to the apical meristem and height growth resumed within 2 weeks of application.

Treatment	Rate of a.i. (kg/ha)	Height* (cm)	Root collar diameter* (mm)	Dry weight* (g)	
				Top	Root
Control	—	10.5^{a}	1.7^{ab}	1.98^{a}	0.75^{a}
Oxyfluorfen	0.25	10.3^{ab}	1.7^{ab}	1.80^{a}	0.63^{ab}
Oxyfluorfen	0.5	9.3^{bc}	1.7^{ab}	1.67^{a}	0.60^{ab}
Oxyfluorfen	1.0	8.6^{c}	1.6^{b}	1.45^{a}	0.51^{b}
Lentagran	0.75	10.0^{a}	1.7^{ab}	1.91^{a}	0.70^{ab}
Lentagran	0.90	10.6^{a}	1.8^{a}	1.91^{a}	0.70^{ab}
Lentagran	1.35	10.3^{a}	1.6^{ab}	1.84^{a}	0.54^{ab}
Lentagran	1.80	10.1^{ab}	1.7^{ab}	1.87^{a}	0.62^{ab}

***Means with similar superscript letters are not significantly different from each other ($P = 0.05$).**

Conclusion: Oxyfluorfen at a.i. rates of 0.5 and 1.0 k/ha applied on actively growing 4-week-old jack pine seedlings will cause needle damage resulting in significant reduction in growth. Subjecting seedlings to lentagran did not result in damage or affect seedling growth. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-20

LANTEIGNE, L.J.; Burns, T.W.; and Hallett, R.D. Effect of sethoxydim on the growth of 4-week-old jack pine and 8-week-old black spruce container seedlings. 1987. (Expert Committee on Weeds – Eastern Section). **Objective:** To study the effect of sethoxydim on the growth of 4-week-old jack pine and 8-week-old black spruce container seedlings and the influence of assist oil, ammonium sulfate, and total spray volume. **Location:** Department of Natural Resources' Forest Nursery, Kingsclear, New Brunswick. **Methods:** ***Site History*** — Jack pine was seeded July 2, 1986, and emerged on July 11, 1986. Black spruce was seeded June 2, 1986 and emerged on June 12, 1986. The herbicide treatments were applied on August 7, 1986, 4 weeks post-emergence for jack pine, and 8 weeks post-emergence for black spruce. Seedlings were 2–4 cm tall with good needle development and color. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Experimental Design*** — Randomized block with five replications. ***Application Specifications*** — Herbicides were applied with a CO_2 regulated sprayer fitted with LP8003 nozzles. Interaction of sethoxydim at a.i. of 0.5 and 0.8 kg/ha, total spray volume at 100 and 486 L/ha, assist oil concentrate (83% oil/17% surfactant) at 2 and 4 L/ha, and liquid ammonium sulfate (486 g/L) at 4 L/ha were evaluated regarding effect on the seedlings. ***Measurements Taken*** — In October 1986, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height (0.1 cm) and root collar diameter (0.1 mm) were measured. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.05$). Oven-dry weight for tops and roots (five trees per replicate grouped) was recorded. Data were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked scores ($P = 0.05$). **Results:** There was no visual damage to jack pine seedlings from any of the treatments. There was no significant decrease in growth that could be attributed to the treatments. In fact, the addition of ammonium sulfate resulted in a significant increase in height (20%) and dry weight for tops (28%). Similarly, there was no visual damage to black spruce seedlings from any of the treatments, nor was there any significant decrease in growth. There was no significant effect of total spray volume (100 L/ha compared with 486 L/ha) on the growth of either black spruce or jack pine seedlings. **Conclusion:** Jack pine and black spruce seedlings are tolerant of sethoxydim (a.i. 0.5 and 0.8 kg/ha), regardless of total spray volume, addition of assist oil, and/or ammonium sulfate. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-21

LANTEIGNE, L.J.; Burns, T.W.; and Hallett, R.D. Effect of oxadiazon and EXP4233 on the growth of black spruce and red spruce container seedlings. 1987. (Expert Committee on Weeds - Eastern Section). **Objective:** To evaluate the tolerance of 10-week-old black spruce and red spruce container seedlings for one and two applications of oxadiazon and EXP4233. **Location:** Department of Lands and Forests Provincial Nursery, Lawrencetown, Nova Scotia. **Methods:** ***Site History*** — Black spruce and red spruce were seeded March 20–21, 1986, emerged April 1, 1986, were grown in the greenhouse until June 2–5, 1986, then moved outdoors. The seedlings were 4–7 cm tall and growing vigorously at the time of treatment. ***Growing Medium*** – Sphagnum peat moss and vermiculite. ***Application Specifications*** — The rates of application for oxadiazon were a.i. at 2.4 and 3.6 kg/ha; rates for EXP4233 were a.i. at 2.2, 2.64, and 3.96 kg/ha. Both herbicides were granular formulations and were applied manually. Single treatments were applied on June 12, 1986. Double treatments were applied on June 12 and August 12, 1986. ***Experimental Design*** — Split-plot randomized block with five replications. ***Measurements Taken*** — In October 1986, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Height (0.1 cm) and root collar diameter (0.1 mm) were measured. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.01$). Oven-dry weight (0.01 g) for tops and roots (five trees per replicate grouped) was recorded. Data were subjected to nonparametric statistics (linear ranking) and variance analysis was performed on ranked scores ($P = 0.01$). **Results:** Oxadiazon and EXP4233 did not have a significant effect on height, root collar diameter, or dry weight of either red spruce or black spruce seedlings. Two applications of the herbicides in one growing season did not significantly affect growth of either species. **Conclusion:** Red spruce and black spruce seedlings are tolerant of single and double applications of oxadiazon (a.i. 2.4 and 3.6 kg/ha) and EXP4233 (a.i. 2.2, 2.64, and 3.96 kg/ha). **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-22

LANTEIGNE, L.J.; Burns, T.W.; and Hallett, R.D. Effect of oxyfluorfen, sethoxydim, and fluazifop-butyl on the growth of red spruce container seedlings. 1987. (Expert Committee on Weeds – Eastern Section). **Objective:** To evaluate the tolerance of red spruce container seedlings for oxyfluorfen, sethoxydim, and fluazifop-butyl. **Location:** Department of Lands and Forests Provincial Nursery, Lawrencetown, Nova Scotia. **Methods:** ***Site History*** — Red spruce was seeded on June 6, 1985, emerged June 14, 1985, was grown in the greenhouse until July 12, 1985 and then moved to a cold frame shelterhouse. Seedlings were actively growing at time of treatment in 1986. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Experimental Design*** — A split-plot randomized block design with five replications. ***Application Specifications*** — Oxyfluorfen, sethoxydim, and fluazifop-butyl were applied at a.i. rates of 0.25, 0.50, and 1.00 kg/ha. Single application treatments were applied on June 3, 1986. Double application treatments were applied on June 3 and August 11, 1986. Herbicides were applied with a CO_2 pressure-regulated sprayer fitted with three LP8003 nozzles delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. ***Measurements Taken*** — In October 1986, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.01$). **Results:** Within 1 week following application there was slight damage to the new needles at the 0.5-kg/ha a.i. rate from all the herbicide treatments. Damage was moderate at the 1.0-kg/ha a.i. rate and was greater following the June 3, 1986 application than after the August 11, 1986 application. Damage was generally greater for the oxyfluorfen + sethoxydim treatments than for the other herbicides. It is noteworthy that these treatments included assist oil concentrate (83% oil/17% surfactant) at 1% of total spray volume. The assist oil enabled the oxyfluorfen to remain on the needles longer and thereby resulted in greater damage to the seedlings. However, there was no damage to the apical meristem and seedlings resumed growth within 2 weeks of herbicide application. **Conclusions:** Oxyfluorfen at a.i. of 0.5 and 1.0 kg/ha can cause needle burn and reduce growth of red spruce seedlings, especially with two applications during one growing season and the addition of assist oil. Oxyfluorfen at a.i. of 0.25 kg/ha can be safely applied to red spruce seedlings 4 weeks post-flush. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-23

LANTEIGNE, L.J.; Burns, T.W.; and Hallett, R.D. Effect of oxyfluorfen, sethoxydim, and fluazifop-butyl on the growth of 4-week-old balsam fir and 8-week-old eastern larch container seedlings. 1987. (Expert Committee on Weeds - Eastern Section). **Objective:** To evaluate the tolerance of 4-week-old balsam fir and 8-week-old eastern larch container seedlings to oxyfluorfen, sethoxydim, and fluazifop-butyl. **Location:** Department of Lands and Forests Provincial Nursery, Lawrencetown, Nova Scotia. **Methods:** ***Site History*** — Balsam fir was seeded November 6, 1985, was placed in shade area for the winter, emerged May 7, 1986, and was grown in cold frame structures. Eastern larch was seeded March 21, 1986, emerged April 1, 1986, was grown in a heated greenhouse, and was moved outside June 5, 1986. Seedlings were actively growing at time of herbicide application on June 2, 1986. The balsam fir seedlings were about 1–2 cm tall with 4-6 needles. The eastern larch seedlings were 6–10 cm tall with 15–25 needles. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Experimental Design*** — Randomized block design with five replications. ***Application Specifications*** — Herbicides were applied with a CO_2 pressure-regulated sprayer fitted with three LP8003 nozzles delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. ***Measurements Taken*** — In October 1986, 5 seedlings per replicate (25 per treatment) were randomly selected for morphological measurements. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.01$). **Results:** No mortality could be attributed to any of the herbicide treatments for either species and the apical meristem was not damaged. There was slight chlorosis of the needles of balsam fir which resulted in a significant reduction in height, root collar diameter, and dry weight for all the herbicide treatments. Within 1 week of herbicide applications, the uppermost needles of the eastern larch seedlings were moderately damaged from the oxyfluorfen and oxyfluorfen + fluazifop-butyl treatments and were severely damaged from oxyfluorfen + sethoxydim. This resulted in a significant reduction in height, root collar diameter, and dry weight.

Treatment	Rate of a.i. (kg/ha)	Height* (cm)	Root collar diameter* (mm)	Dry weight* (g) Top	Dry weight* (g) Root
		Balsam Fir			
Control	–	5.2^{a}	1.6^{a}	0.73^{a}	0.53^{a}
Oxyfluorfen	0.5	4.2^{b}	1.4^{b}	0.26^{b}	0.16^{b}
Oxyfluorfen +fluazifop-butyl	0.5	4.5^{b}	1.2^{b}	0.29^{b}	0.17^{b}
Oxyfluorfen +sethoxydim**	0.5	4.7^{b}	1.3^{b}	0.31^{b}	0.19^{b}
		Eastern Larch			
Control	–	35.4^{a}	3.8^{a}	7.10^{a}	1.66^{a}
Oxyfluorfen	0.5	31.6^{b}	3.5^{b}	5.55^{a}	1.15^{b}
Oxyfluorfen +fluazifop-butyl	0.5	32.7^{b}	3.5^{b}	6.10^{a}	1.20^{b}
Oxyfluorfen sethoxydim**	0.5	30.8^{b}	3.4^{b}	5.73^{a}	1.08^{b}

*Means with similar superscript letters are not significantly different from each other ($P = 0.01$).

**Assist oil concentrate (83% oil/17% surfactant, BASF) was added at 1% of total spray volume.

Conclusions: Additional research is required to study the effect of these herbicides on the growth of balsam fir and eastern larch. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-24

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. The tolerance of black spruce container seedlings to oxyfluorfen. 1988. (Expert Committee on Weeds - Eastern Section). **Objective:** To study the effect of oxyfluorfen on black spruce container seedlings **Location:** Department of Natural Resources' Nursery, Kingsclear, New Brunswick. **Methods:** ***Site History*** — Black spruce was seeded and grown in the greenhouse during 1986. The seedlings were placed in an outdoor holding area for the winter of 1986–87. The experiment was conducted in spring 1987. The seedlings were 5–6 cm in height at this time. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Experimental Design*** — Randomized split-plot with five replications. ***Application Specifications*** — Oxyfluorfen was applied with a CO_2 pressure-regulated sprayer fitted with three LP8003 nozzles delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. Rates of application were at a.i. of 0.25, 0.5, and 1.0 kg/ha. Treatments were applied at pre-flush, 3–4 weeks post-flush and 7–8 weeks post-flush. ***Measurements Taken*** — In September 1987, 10 trees per replicate (50 per treatment) were randomly selected for morphological measurements. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test ($P = 0.01$). **Results:** Oxyfluorfen applied 3–4 weeks and 7–8 weeks post-flush caused burning of needles immediately below the shoot apex, with a direct relationship between rate and severity of injury. Needle damage for the 3–4 weeks post-flush treatment was greater than the 7–8 weeks post-flush treatment. Height growth resumed and by the end of the growing season the needle damage was hardly noticeable. There was no significant reduction in growth with any of the treatments. **Conclusion:** Application of oxyfluorfen (a.i. 0.25, 0.5, 1.0 kg/ha) on overwintered black spruce seedlings applied at pre-flush, 3–4 weeks post-flush, and 7–8 weeks post-flush may result in slight needle burn but no significant reduction in growth. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-25

LANTEIGNE, L.J.; Burns, T.W.; Hallett, R.D. The tolerance of red spruce seedlings to oxyfluorfen. 1988. (Expert Committee on Weeds - Eastern Section). **Objective:** To study the effect of oxyfluorfen on red spruce container seedlings. **Location:** Department of Lands and Forests Nursery, Lawrencetown, Nova Scotia. **Methods:** ***Site History*** — Red spruce was seeded and grown in the greenhouse during 1986. The seedlings were placed in an outdoor holding area for the winter of 1986–87. The experiment was conducted in spring 1987 when the seedlings were 18–21 cm in height. ***Growing Medium*** — Sphagnum peat moss and vermiculite. ***Experimental Design*** — Randomized split-plot with five replications. ***Application Specifications*** — Oxyfluorfen was applied with a CO_2 pressure-regulated sprayer fitted with three LP8003 nozzles delivering a total spray volume of 486 L/ha at an operating pressure of 138 kPa. Rates of application were a.i. at 0.25, 0.5, and 1.0 kg/ha. Treatments were applied at pre-flush, 3–4 weeks post-flush, and 7–8 weeks post-flush. ***Measurements Taken*** — In September 1987, 10 trees per replicate (50 per treatment) were randomly selected for morphological measurements. Data were subjected to variance analysis and means were separated using Student–Newman–Keul's multiple-range test (P = 0.01). **Results:** Oxyfluorfen applied 3-4 weeks and 7–8 weeks post-flush caused burning of needles immediately below the shoot apex, with a direct relationship between rate and severity of injury. Needle damage for the 3–4 weeks post-flush treatment was greater than the 7–8 weeks post-flush treatment. Height growth resumed and by the end of the growing season the needle damage was hardly noticeable. There was no significant reduction in growth with any of the treatments. **Conclusion:** Application of oxyfluorfen (a.i. 0.25, 0.5, 1.0 kg/ha) on overwintered red spruce seedlings applied at pre-flush, 3–4 weeks post-flush, and 7-8 weeks post-flush may result in slight needle burn but no significant reduction in growth. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. C-26

SALONIUS, P.O.; Murray, T.S.; Beaton, K.P. Influence of deep rototilling site preparation on containerized conifer growth as compared to crushing site preparation. 1981–89. Objective: To study the influence of deep tilling on conifer and associated vegetation growth. **Location:** Boiestown, New Brunswick (J.D. Irving Crown lease). **Methods:** ***Site History*** — Mixed spruce-fir stand with white pine, tamarack, and maple admixture, conventional clearcut 1979, entire site crushed 1980, strips tilled (Madge Rotoclear, 2.3 m swath), July 1981. Tilled and untilled strips planted with winter greenhouse-grown (24 weeks) jack pine, white spruce, black spruce, and red spruce in paperpots, styroblock no. 2, styroblock no. 4, styroblock no. 8, and styroblock no. 20 in July 1982. Competition at time of tilling consisted of raspberry, pin cherry, bracken, grass, hobblebush, softwood seedlings, hardwood stump sprouts, and others. ***Soils*** — Sandy loam, somewhat stony (sandstone), glacial till; moderately well drained with duff layer 5–7.5 cm thick . ***Application Specifications*** — No herbicide applied. ***Experimental Design*** — Fifty seedlings per container type of the four species in individual tilled or untilled strips, no replication. ***Measurements Taken*** — Seedling height, root collar diameter, rainfall during plantation year, and soil temperature at surface and 5, 10, 15, 20, 30, and 45 cm below surface. Photographic record of vegetation status (tilled and untilled). **Results:** Initial seedling size advantage of larger container cavities maintained up to 1987 (last measurement). Volume growth on tilled twice that on untilled. Raspberry (main competitor) reinvaded tilled soil slowly and with poor vigor. **Conclusions:** On this site, deep tilling is more effective than one glyphosate application at similar cost. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)**

SALONIUS, P.O.; Murray, T.S.; Beaton, K.P. Influence of operational glyphosate timing in annual sequence before and after planting on conifer plantation growth. 1985-P. **Objective:** To study the effects of operational spraying of glyphosate (Roundup®/Vision®) for control of competing vegetation in a sequence of years before and after planting. **Location:** Twelve plantation sites in New Brunswick. **Methods:** ***Site History*** — All sites previously forested, clearcut, prepared by several methods in 1985, and planted to a variety of conifer species early 1986. Six treatments, consisting of (1) control (no treatment), (2) spray 1985, (3) spray 1986, (4) spray 1987, (5) spray 1988, and (6) "total" spray whenever significant amount of associated vegetation present until 1988. ***Soils*** — Depend on areas chosen. ***Application Specifications*** — Glyphosate, by fixed-wing aircraft, at 4.2 L/ha. ***Experimental Design*** — Randomized block spray-swath-width strips, wide buffers, no replications, 150 subject seedlings per strip. ***Measurements Taken*** — Seedling height, height of base of live leader, mean height of competitors within 1 m, notation of competing species of first, second, and third importance within 1 m, height of tallest individual of each of these within 1 m, and percentage of colored squares on metal bar set at base of leader seen by observer 2.3 m south of seedling. In 1989, root collar diameters will also be taken. **Results:** Some of the operational spray applications were effective, some were not, some were missed entirely because of administrative errors. **Conclusions:** None so far (looking for relationships between competition index and growth). **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)**

WALL, R.E. Hardwood stump treatments with *Chondrostereum purpureum* to control sprouting. 1985–89. Objectives: To test the potential of the fungus *Chondrostereum purpureum* as a bioherbicide for stump sprout control. **Location:** Fredericton, N.B. **Methods:** ***Site History*** — Two young, 12–15-year-old hardwood stands originating from a large clearcutting operation and located 2 km apart in the Nashwaak watershed were used. One consisted mainly of tolerant hardwoods (beech, sugar maple, striped maple, yellow birch), while the other consisted of the intolerant hardwoods (trembling aspen, paper birch, pin cherry, and red maple). ***Experimental Design*** — Plots were established in three replicate blocks and were 0.004 ha. During the latter part of July all trees in each plot were felled and petri dish cultures of *C. purpureum*, isolated from the same stand, were placed over each stump. In the control plots stumps were left untreated. During the subsequent 2 years stumps were examined for the presence of the fungus and the number of living stump sprouts counted. **Results:** Percentage of stumps with living sprouts 1 and 2 years after inoculation (number of stumps in parentheses):

Stand	Years after inoculation	Inoculated	Control
Tolerant	1	39 (41)	72 (61)
	2	3*	26
Intolerant	1	67 (50)	92 (33)
	2	19	48

*Significantly different from the control at $P = 0.05$.

Two years after treatment, no living sprouts remained on treated stumps that showed evidence of infection (fruiting of the fungus on the stump surface) within 1 year after treatment. In the tolerant and intolerant hardwood stands, respectively, 3 and 19% of the treated stumps and 26 and 48% of the untreated stumps had living stump sprouts after 2 years. Stumps of all hardwood species were invaded by the fungus and showed some reduction of sprouting. Paper birch showed the greatest response and aspen the least. **Conclusions:** *Chondrostereum purpureum* cultures could provide a reliable control for regrowth of hardwoods. Further investigation of methods of culture and application as well as potential effects on nontarget species is required. **(New Brunswick Department of Natural Resources and Energy; Valley Forest Products Ltd.; and Forestry Canada, Maritimes Region, Fredericton, New Brunswick)**

WALL, R.E.; Simpson, R.A. Hardwood stump treatments with fungi to control sprouting. 1986–87. **Objective:** To determine the feasibility of using living cultures of pathogenic fungi and slash rotters to hasten stump mortality and retard sprouting. **Location:** Nackawic, New Brunswick. **Methods:** ***Site History*** — The site had been occupied by mature hardwood and mixedwood stands which were clearcut between 1971 and 1975. The dense hardwood regeneration which resulted (aspen, balsam poplar, paper birch, yellow birch, red maple, sugar maple, striped maple, pin cherry, white ash, and beech) was undergoing operational spacing treatments when the treatments were applied. ***Experimental Design*** — Spacing was carried out with a brush saw to achieve a stocking of approximately 2000 stems/ha. Stumps were treated within 1 hour after felling with oil slurries of 1-month-old cultures growing on wheat bran. Oils used were heavy mineral oil, SAE no. 10W30 motor oil, and summer-grade chainsaw oil. Two isolates of the pathogenic fungus Chondrostereum purpureum and one isolate each of the slash rotters Irpex lacteus and Polyporus versicolor were tested. All were isolated from local forest stands. Treatments were repeated during June and July 1986. In 1987, treated stumps were compared with nearby untreated stumps for fruiting bodies of the fungi used for inoculation, and for the presence of living stump sprouts. **Results:** Percentage of stumps with living sprouts 1 year after inoculation (number of stumps in parentheses):

Treatment	Date	Treated	Untreated
C. purpureum no. 1 in 10W30 motor oil	May 27	32 (75)	64 (67)
C. purpureum no. 1 in mineral oil	May 29	33 (66)	66 (105)
C. purpureum no. 2 in mineral oil	May 29	41 (54)	66 (105)
I. lacteus in mineral oil	May 29	68 (50)	66 (105)
P. versicolor in mineral oil	May 29	57 (89)	66 (105)
Sterile bran in mineral oil	May 29	36 (25)	66 (105)
C. purpureum no. 1 in 10W30 motor oil	June 3	54 (35)	87 (67)
C. purpureum no. 1 in mineral oil	June 3	25 (40)	87 (67)
C. purpureum no.1 in mineral oil containing 17% surfactant	June 3	62 (37)	87 (67)
C. purpureum no. 1 in chain saw oil	June 10	50 (26)	–
I. lacteus in chainsaw oil	June 10	60 (35)	–
Sterile bran in chainsaw oil	June 10	72 (36)	–

Fruiting of *C. purpureum* was observed on stumps inoculated with that fungus but none of the other treatments showed evidence of infection 1 year after treatment. Counts in the first plot (*C. purpureum* no.1 in 10W30 motor oil inoculated May 27, 1986, and again in September 1987) indicated that 24% of the treated stumps and 82% of the untreated stumps had living sprouts. Further observations will be made at the earliest opportunity. **Conclusions:** Treatment of stump surfaces with oil slurries of fungi shows some promise in hastening stump mortality and controlling regrowth by stump sprouts. Although *C. purpureum* shows the most promise in these early observations, other fungi and methods of application should be tested. There is some evidence that surfactant-free oils should be used and that oils alone can hasten stump death. **(Forestry Canada, Maritimes Region, Fredericton, New Brunswick)** Publ. No. A-38

Chapter 4. Quebec Region Summaries

DELISLE, C. Growth and survival response following a conifer-release treatment with glyphosate. 1982–87. **Objective:** To study the effects of glyphosate (Roundup®) on the growth and survival of jack pine and Scots pine container seedlings planted 2 years before treatment. **Location:** Grand-Mère, Quebec, Lower Saint-Maurice Management Unit; elevation 93 m. **Methods:** ***Site History*** — Farmland before 1926, when planted with white spruce. Clearcut in 1980. Planting spots were prepared in the spring of 1982 with a Bräcke scarifier, and planted June 9 and September 10, 1982, with jack pine and Scots pine Styroblock-8 and Quebec tube stock. On August 22, 1984, three-fifths of the experimental plots were sprayed with glyphosate. Competition at the time of treatment consisted of trembling aspen, red maple, pin cherry, white birch, red raspberry, acuminate aster, and fireweed. ***Soils*** — Deep fine to medium well-drained sand. ***Application Specifications*** — Glyphosate was applied with Echo backpack sprayer. Active rate of 2 kg/ha was applied in water totaling 270 L/ha. ***Experimental Design*** — Factorial design with four replications was followed for plantation. Nineteen plots out of 32 were sprayed. About half of each block was treated without considering the initial design. Each plot consisted of 121 seedlings with a 2 m × 2 m spacing. ***Measurements Taken*** — Survival measurements and evaluation of the quality of the seedlings were made during spring 1983, 1985, and 1987 for each seedling. Height growth and root collar diameter of 213 treated trees and 117 untreated trees were measured in September 1987. **Results:** Growing seasons were considered in the height and root collar diameter growth study instead of calendar year. Treatments resulted in an increase in survival for jack pine (18.7% dead trees for treated plots against 24% for untreated plots) and for Scots pine (12.3% against 22.3%); an increase in height growth was found for jack pine (163.5 cm against 146.8 cm for untreated trees) but no difference for Scots pine (96.2 cm for treated trees against 96.6 cm for untreated trees); an increase in collar diameter was found for jack pine (56.8 mm against 39 mm for June planting and 40.9 mm against 23.8 mm for September planting) and for Scots pine (34.1 mm against 32 mm for June planting and 33 mm against 23 mm for September planting). **Conclusions:** Glyphosate treatment reduced mortality rate of seedlings and increased height and collar diameter growth especially for jack pine. The nonsignificant difference in height growth for Scots pine was explained by browsing of terminal leaders by deer, which was recorded in greater frequency on Scots pine during the spring. **(Forestry Canada, Quebec Region, Sainte-Foy, Quebec)**

ROBERGE, M.R. Manual crop tree release in Estrie, 30 years of studies and results. 1962-88. **Objective:** To learn how various tree species, established naturally or artificially and of different ages and crown positions, respond to intensities of release as measured by survival and growth in diameter, height, and and bole quality. **Location:** Dudswell Experimental Forest, Estrie, Quebec; elevation between 280 and 400 m. **Methods:** Sugar maple, yellow birch, and balsam fir stands were harvested annually between 1962 and 1986 using the clearcutting and shelterwood methods and areas of various sizes and forms. Some sites were prepared and some were planted with yellow birch, red oak, red spruce, Norway spruce, red pine, or European larch. Release treatments took place 2, 5, 10, 15, or 20 years after harvesting using secateurs, knives, small chain saws, or brushcutters depending on the size of competition and the intensity of release. **Results:** The best compromise between survival, growth rate, and quality development without corrective pruning is to release within the radius of the bole of selected crop trees. For tolerant species, the radius is 10 times the dbh of the crop tree, for semitolerant species it is 12.5 times, and for intolerant species, it is 15 times. For each metre that the competition is higher than the crop tree, the radius is increased by 25%. All vegetation that is less than half the height of the crop tree must not be cut. When possible the competing vegetation must be cut at a height only half that of the crop tree; it must never be cut at ground level. With corrective pruning, a radius 50% greater would be best because diameter growth is 30% greater. The best age or size to release is 5 years after harvesting or when crop trees or vegetation are about 2 m high; codominant and intermediate crop trees respond best. **(Forestry Canada, Quebec Region, Sainte-Foy, Quebec)**

UNG, C.H. Enrichment of degraded stands in the Témiscouata area. 1988-P. Objective: To determine the optimum degree of forest cover opening through sanitation cutting to control the proliferation of competing vegetation and to accelerate the establishment and growth of the species introduced to enrich the degraded stands. **Location:** JAL, Témiscouata, Quebec; elevation 350 m. **Methods:** ***Site History*** — Timber forest approximately 50 years old consisted essentially of sugar maple from earlier overcutting. A sanitation cut was made in the summer of 1987 over two 0.25-ha blocks. Red oak acorns were sown in the fall of 1987 over part of the first block. Norway spruce seedlings were planted in the remainder of the first block and all of the second block in the spring of 1988. Competing vegetation at the time of planting was mostly mountain maple and striped maple. ***Soils*** — Loamy and stony, 45 cm deep, with 6 cm of humus. ***Vegetation Control*** — Initially cultural treatment with proportioning of sugar maple cover opening by sanitation cutting and, where necessary, manual clearing. ***Experimental Design*** — Two blocks measuring 50 × 50 m. Each block is stratified in terms of degree of cover opening. ***Measurements*** — For each reserved tree, rectangular coordinates, crown projection, height, and dbh are measured. For competing vegetation, height and density are to be measured twice a year from 1988 to 1992. For introduced seedlings, height and collar diameters are to be measured once a year from 1988 to 1992. **(Forestry Canada, Quebec Region, Sainte-Foy, Quebec)**

Chapter 5. Ontario Region Summaries

ROBERTS, J.R.; Loud, P.M.; Stemeroff, M.; Stephenson, G.R.; Sutton, R.F.; Ales, C.R.; Edgington, Q.V.; Payandeh, B. Evaluation of the biological and economic benefits of pesticide use. 1985-P. Associate Committee on Scientific Criteria for Environmental Quality. National Research Council of Canada, Publication NRCC No. 23988, 293 p. **Abstract:** The strengths and limitations of current measures of benefits resulting from pesticide use, the economic evaluation of this yield benefit, and its subsequent distribution among different sectors of society are examined. Benefit analyses were performed for three case studies: captan on strawberries in British Columbia; fonofos on onions in Ontario; and 2,4-D/2,4,5-T on coniferous forests in New Brunswick. It was concluded that based on current data, estimates of benefits or costs associated with a particular pest control are not a particularly useful tool in the decision-making process. Data on yield benefits as a function of crop, climate, and pest incidence on a regional basis are lacking, as is regional documentation on the level of pest infestation, total crop hectarage, and the hectarage requiring pest control. The methodology to estimate economic benefits at a producer or regional level is available, but not for estimation at the national level. Economic information lacking includes descriptions of market structures, supply and demand functions (elasticities) for the commodity and associated input markets, cultural practices, input costs, pesticide usage patterns, and actual marketed yield of major crops. Currently such information must be collected on an ad hoc basis for each benefit-cost study. **(Forestry Canada, Ontario Region, Sault Ste. Marie, Ontario)** Publ. No. A-27

SUTTON, R.F. Black spruce and jack pine underplanted through sapling hardwoods: effect of Arsenal®. 1982–88. **Objective:** To determine the feasibility of establishing black spruce, jack pine, or both by underplanting through sapling hardwoods with post-planting over-the-top application of Cyanamid herbicide AC 252,925, subsequently designated Arsenal®. **Location:** Sault Ste. Marie, Ontario; 210 m elevation. **Methods:** ***Site History*** — Sapling stand of presumably root sucker origin consisting of large-tooth and trembling aspen about 10 years old, with some hazel and bracken present. ***Soils*** — Deep outwash sand. ***Application Specifications*** — a.i. at 0.0, 0.5, 0.75, 1.0, and 1.25 k/ha + surfactant applied by backpack sprayer in spring or summer. ***Experimental Design*** — Plots 10 x 10 m split between black spruce and jack pine in randomized blocks with two replications; 16 paperpot seedlings of each species per plot planted in May 1982; herbicide applied late May or late July 1982. ***Measurements Taken*** — Jack pine were virtually eliminated within 1 year because of browsing by hares; black spruce performance has been determined annually, vegetation changes have been recorded qualitatively. **Results:** By 1985, annual height increment of spruce in treated plots was about double that in untreated plots and was increasing with time in the treated plots, decreasing in the untreated. Spring application damaged leading shoots but did not kill the spruce, which subsequently responded to canopy reduction. **Conclusions:** Underplanting without canopy reduction did not succeed in these conditions; Arsenal® applied in spring or summer effected a slow, silviculturally beneficial reduction in canopy. **(Forestry Canada, Ontario Region, Sault Ste. Marie, Ontario)**

SUTTON, R.F. Hexazinone Gridballs® applied with concurrent underplanting of white spruce in boreal mixedwoods: 7-year results. 1978–88. **Objective:** To study the feasibility of establishing white spruce by underplanting in boreal mixedwoods treated only with Gridballs® at the time of planting. ***Location:*** Chapleau, Ontario; 400 m elevation. **Methods:** ***Site History*** — (a) Fawn Twp., stand mainly jack pine–trembling aspen harvested for conifer 1970–71; (b) Highbrush Lake, mature mixedwood (aspen, birch, spruce, fir) stand burned 1967. ***Soils*** — (a) mildly acid, deep, till-influenced sand outwash; (b) mildly acid, deep sandy loam till, stony to very stony, with pockets of silty loam. ***Application Specifications*** — 2-cm^3,10% Gridballs® (i.e. 10% hexazinone by mass), 3.75 g per pellet, placed manually on the forest floor without disturbance at grid spacings of 1.63 × 1.63 m and 0.95 × 0.95 m in June 1978 concurrently with outplanting of 16 white spruce, in a 4×4 block at the center of each 10 × 10 m treated plot, at the same but offset spacings. ***Experimental Design*** — Randomized blocks, two replications. ***Measurements Taken*** — Initial vegetation survey; at least annual assessment of white spruce performance for first 7 years; resurvey of vegetation 10 years after initial. **Results:** Up to 7th year reported in For. Chron. 62:226–232, 1986. **Conclusions:** The evidence is persuasive that white spruce plantations may be established in the boreal mixedwoods by underplanting and, in the same operation, applying Gridballs® (or other similarly effective herbicide) at 1 × 1 m spacing. **(Forestry Canada, Ontario Region, Sault Ste. Marie, Ontario)** Publ. No. A-35

WOOD, J.E. Chemical tending of boreal black spruce plantations with glyphosate (Roundup®). 1981-P. **Objectives:** To define required grades of black spruce container stock for various site conditions and seasons of planting and to define post-planting vegetation control treatments for important site conditions. **Location:** (a) Foleyet, Ontario; 335 m elevation; (b) Matheson, Ontario; 260 m elevation; (c) Cochrane, Ontario; 275 m elevation. **Methods:** ***Site History*** — (a) mature mixedwood stand (spruce, cedar, fir, aspen, birch), spruce harvested 1979–80, mechanically site-prepared summer 1981 by straight blade mounted on a crawler tractor; (b) mature mixedwood stand (fir, spruce, birch, aspen), conifer component harvested in 1979–80, mechanically site-prepared in February 1982 with a shearing-type blade mounted on a crawler tractor; (c) mature mixedwood stand (spruce, aspen, fir), conifer component harvested 1981, mechanically site-prepared in winter of 1981–82 with shearing-type blade mounted on crawler tractor. ***Soils*** — (a) 5- to 7-cm-thick humus layer, loamy to silty sand soils (pH 5.0), fresh to moderately fresh moisture regime; (b) 2- to 10-cm-thick humus layer, clay soils (pH 5.5), very fresh moisture regime; (c) 5- to 10-cm thick humus layer over silt loam to clay loam (pH 5.3), moderately moist to moist moisture regime. ***Planting Stock*** — Bareroot 1.5 + 1.5 transplant stock, 11-month-old FH408 Japanese paperpots, and 15-month-old FH408 Japanese paperpots planted May 1982; bareroot 1.5 + 2.0 transplant stock, 5-month-old FH408 Japanese paperpots, and 6-month-old FH408 Japanese paperpots planted in July 1982. ***Application Specifications*** — (a) and (b) glyphosate, a.i. at 2.14 kg/ha, applied late August 1984 to plots containing 50 outplants. Glyphosate applied with Herbi® hand-held low-volume sprayer, swath width 1.75 m, water carrier, total spray volume 60 or 68 L/ha; (c) glyphosate, a.i. at 2.5 kg/ha, applied late August 1982 or 1983 to plots containing 50 outplants. Glyphosate applied in 1982 with a piston pump equipped with OC20 cluster nozzle mounted on a Nodwell Flextrac carrier, 159 kPa pressure, water carrier, 591 L/ha total spray volume. Cooper CP15 backpack sprayer used for 1983 application, 207 kPa pressure, water carrier, 300 L/ha total spray volume. ***Experimental Design*** — Randomized complete block; (a) and (b) three replications, (c) two replications. ***Measurements Taken*** — Survival, condition, total height, and height increment of outplants measured after first, second, third, and fifth growing seasons; stem diameter also measured after fifth growing season; qualitative pre- and post-spray vegetation surveys. **Results:** Work in progress. **(Forestry Canada, Ontario Region, Sault Ste. Marie, Ontario)**

WOOD, J.E.; Campbell, R.A. Black spruce outplantings in boreal Ontario: chemical site preparation with hexazinone. Objective: To evaluate the potential of hexazinone (Velpar® L) as a site-preparation tool on fertile upland boreal mixedwood sites. **Location:** Five experiments were established across northeastern Ontario - (a) Matachewan, 305 m elevation; (b) Matachewan, 305 m elevation; (c) Matheson, 260 m elevation; (d) Hearst, 245 m elevation; (e) Matheson, 260 m elevation. **Methods:** ***Site History*** — (a) and (b) mixedwood stand (aspen, birch, spruce, pine, fir), cut for conifer in 1959–62, then subjected to several ineffective attempts at chemical and mechanical site preparation, burned by wildfire in 1977, and unsuccessfully seeded to jack pine; (c) mixedwood stand (fir, aspen, spruce, birch), cut for conifer in 1980–81, site-prepared in March 1981 with a shearing-type blade mounted on a crawler tractor; (d) mixedwood stand (spruce, aspen, birch), cut for conifer 1975, site-prepared in March 1981 with a shearing-type blade mounted on a crawler tractor; (e) mixedwood stand (spruce, aspen, birch, fir), cut for conifer 1980–81, not mechanically site-prepared. ***Soils*** — (a) deep silt loam, moisture regime fresh to very fresh; (b) deep silt loam, moisture regime very moist; (c) deep silty clay, moisture regime moderately moist to very moist; (d) shallow sandy clay loam to deep clay loam, moisture regime very fresh on shallow crests to very moist in depressions; (e) silty clay soils, moderately to very moist. ***Planting Stock*** — Bareroot 1.5+1.5 transplant and 1-year-old FH408 Japanese paperpot stock planted up to 4 weeks (and in some experiments also about 1 year) after chemical site preparation. ***Application Specifications*** — (a) a.i. at 0.0, 4.5, and 9.0 kg/ha, applied before emergence of green foliage by a ground sprayer mounted on a skidder equipped with a Boom Jet® 5880-OC20 boomless cluster nozzle, 15-m swath width, water carrier with total spray volume of 382 L/ha; (b) a.i. at 0.0, 1.1, 2.2, and 4.5 kg/ha, applied before emergence of green vegetation by a rotary-wing aircraft flying at 97 km/h and equipped with 24 D-7 nozzles (on a skid-mounted boom) oriented back 45° below horizontal and operated at a pressure of 210 kPa, 20-m swath width, water carrier with a total spray volume of 39 L/ha; (c) and (d) a.i. at 0.0, 1.0, 2.0, and 4.0 kg/ha, applied before emergence of green foliage by a rotary-wing aircraft flying at 97 km/h equipped with thirty 6508-flat-fan nozzles on a skid-mounted boom, oriented back 45° below horizontal and operated at a pressure of 240 kPa, 15-m swath width, water carrier with total spray volume of 35 L/ha; (e) a.i. at 0.0, 2.0, and 4.0 kg/ha applied after emergence of green vegetation by a rotary-wing aircraft flying at 89 km/h, equipped with twenty-nine 6508-flat-fan nozzles (on a skid-mounted boom) oriented straight back and operated at a pressure of 200 kPa, 15-m swath width, water carrier with total spray volume of 35 L/ha. ***Experimental Design*** — Completely randomized, crop tree plots replicated 3–5 times. ***Measurements Taken*** — Survival, total height, height increment, and condition of crop trees assessed after first, second, third, and fifth growing season, stem diameter also measured after fifth growing season, vegetation assessed annually. **Results:** Reporting in progress. **(Forestry Canada, Ontario Region, Sault Ste. Marie, Ontario)**

WOOD, J.E.; Sutton, R.F.; Weldon, T.P.; Rissanen, H. Jack pine establishment: effect of stock type, Bräcke scarification, mounding, and chemical site preparation, 3-year results. 1983–88. **Objective:** Self-evident from title **Location:** 200 km N of Sault Ste. Marie, Ontario; 325 m elevation. **Methods:** ***Site History*** — Scattered individuals and small clumps of aspen, black spruce, and black spruce; and abundant grasses, blueberries, strawberry, and bracken. ***Soils*** — Deep glaciofluvial silt loams. ***Application Specifications*** — Roundup® applied in 1.5% aqueous solution at a.i. of 2.0 kg/ha (Roundup® 5.6 L/ha) to circular patches 1.4 m diameter, August 30–31, 1983, using backpack sprayers. Jack pine were planted in May 1984. ***Experimental Design*** — Twenty treatments, plots split by stock type, with 20 bareroot and 20 paperpot trees per plot, in four randomized blocks. ***Measurements Taken*** — Crop performance assessed immediately after planting and after each of the first three growing seasons; qualitative observation of other vegetation. **Results:** After three growing seasons, paperpot stock was larger than the bareroot stock had been after two; paperpot stock responded more strongly than bareroot to mechanical site preparation; both stock types responded positively to mounding; growth responses were consistently in favor of chemical site preparation. **Conclusions:** Consistently beneficial growth responses were obtained with chemical site preparation. **(Forestry Canada, Ontario Region, Sault Ste. Marie, Ontario)**

WOOD, J.E., von Althen, F. W.; Campbell, R.A. Competition control with Pronone® applied in winter. 1985-P. **Objective:** To determine the feasibility of applying Pronone® (granular hexazinone) in the winter, its effectiveness in competition control and site preparation for black spruce outplants **Location:** Matheson, Ontario; 260 m elevation **Methods:** ***Site History*** — (a) 1985 experiment, mixedwood stand (spruce, fir, aspen, birch), cut for conifer 1984, mechanically site-prepared in February 1985; (b) 1986 experiment, see (a) for stand description, conifer component harvested in 1986, mechanically site-prepared February 1986; (c) 1987 experiment, see (a) for stand description, conifer component harvested in 1981, mechanically site-prepared in February 1987; (a), (b), and (c) mechanically site-prepared with a shearing-type blade mounted on a crawler tractor. ***Soils*** — (a) deep clay to sandy clay loam, moisture regime moderate to very moist; (b) deep clay with pockets of sandy clay loam, moisture regime very moist; (c) deep clay to sandy clay loam, moisture regime moist to very moist. ***Planting Stock*** — black spruce 1.5 + 1.5 transplants and 1-year-old FH508 Japanese paperpots planted the first spring following herbicide application or planted the first and second springs following herbicide application. ***Application Specifications*** — Pronone® applied to frozen ground in freshly bladed strips, (a) a.i. at 0.0, 2.0, and 4.0 kg/ha for both 5G (i.e. 5% hexazinone by weight) and 10G formulations applied with Herd Seeder® mounted on a three-wheel all-terrain vehicle, (b) and (c) a.i. at 0.0, 2.0, 4.0, and 6.0 kg/ha (10G formulation) applied with Herd Seeder® mounted on a four-wheel all-terrain vehicle. ***Experimental Design*** — Randomized complete block, (a) three replications, (b) and (c) four replications. ***Measurements Taken*** — Survival, condition, height, and diameter of black spruce outplants measured annually for the first 3 years, vegetation assessed annually. **Results:** Preliminary results for experiment (a) reported in OFRC Symp. Proc. O-P-16 (p. 110); reporting on 3rd-year data from (a) and (b) and 2nd-year data from (c) in progress **(Forestry Canada, Ontario Region, Sault Ste. Marie, Ontario)**

Chapter 6. Forest Pest Management Institute Summaries

FENG, J.; Feng, C. Fate of hexazinone in a New Brunswick Forest. 1984–86. **Objective:** To determine deposition, drift, persistence, degradation, and mobility of herbicide hexazinone in a forest ecosystem. **Location:** Near St. Leonard, New Brunswick. **Methods:** A clear-cut site was treated with Velpar® L (25% hexazinone) at nominal rate of a.i. 3.8 kg/ha by a fixed wing aircraft equipped with a conventional boom and nozzles (application date. May 19, 1984; soil type. loam — 47.8% sand, 32.5% silt, 19.6% clay; only about 15% of the soil cores contained an organic layer separable from mineral horizons). Hexazinone residues were determined by gas chromatography for the on- and off-target deposition, persistence and degradation in soils, and dissipation in stream water. **Results:** On-target deposit monitored with 400-cm^2 plates at soil plots was highly variable, averaging a.i. of 2.53 kg/ha with 37% C.V. ($n=16$). Off-target deposit decreased rapidly to 0.85, 0.31, 0.18, 0.067, 0.050, 0.006, and a.i. of 0.006 kg/ha at 10, 20, 30, 40, 50, 75, and 100 m downwind. Log-log hexazinone residue disappearance relationships with time (up to 537 days after application; 11 sampling periods) were found with correlation coefficients of the means (4 replicates) ranging from $r = 0.88$ to 0.98, with 50% of the initial residues calculated to remain after 8, 28, and 13 days for upper (0–15 cm), lower (15-30 cm), and their combined (0–30 cm), soil layers, respectively; and with 10% to remain after 49, 319, and 122 days, respectively. Equations illustrating temporal dissipation of hexazinone in New Brunswick loam soils at different depths are as follows:

Soil layer	Soil depth (cm)	Linear regression equation*	Correlation coefficient	No.
Total	0 - 30	log Wa = 0.781 - 0.711 log D	0.953	9
Upper	0 - 15	log Wa = 0.803 - 0.891 log D	0.980	9
Lower	15 - 30	log Wa = 0.288 - 0.605 log D	0.879	9
Upper	0 - 15	log Ww = 0.743 - 0.887 log D	0.975	9
Lower	15 - 30	log Ww = 0.130 - 0.563 log D	0.876	9

* Wa = Hexazinone residues on areal basis (kg/ha); D = days after application;
Ww = Hexazinone residues on weight basis (mg/g).

Hexazinone leaching to the lower soil layer depended on rainfall, and peaked at a.i. of 0.6 kg/ha (a.i. 0.46 mg/g) after 6 days when cumulative rainfall reached 29 mm. Hexazinone residues were detected in streamwater throughout the 45 days when runoff in six storm events was monitored. Residues decreased both with time after application and with distance downstream. The initial peak concentration at 50 m downstream was 30.8 ppb during the first storm event 6 days after application, and decreased rapidly to 3.7 ppb after 45 days; concentration at 800 m downstream was 5.1 ppb during the second storm event 13 days after application, and decreased to less than 1 ppb between 20 and 45 days after application. No residues were found at 1500 m downstream throughout the monitoring period. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

KREUTZWEISER, D.P.; Kingsbury, P.D.; Feng, J.C. Drift response of stream invertebrates to aerial applications of glyphosate. 1984–85 **Objective:** To study the short-term effects of glyphosate on stream invertebrates by measuring drift response. **Location:** Carnation Creek watershed, Vancouver Island, B.C. **Methods:** A total of 42 ha of the watershed was aerially treated with 2 kg/ha glyphosate. Three sites were selected for sampling invertebrate drift: (1) in the main channel of Carnation Creek near B-weir, located 500 m above the estuary and downstream of most treated portions of the valley; (2) in C-Creek, located 2000 m above the estuary, and (3) in 1600-tributary, located 1600 m above the estuary. Site 1 and 2 were buffered by a 10 m no-spray zone, while site 3 was intentionally oversprayed. Stream water was collected at 22 time periods for determining glyphosate residues. **Results:** Drift densities of most aquatic invertebrates did not increase in response to the glyphosate applications. None of the post-spray mean drift values for total invertebrate catches were significantly higher than pre-spray mean densities ($P > 0.05$). Heavy rainfall and high water conditions at both the beginning and end of the sampling period accounted for most of the variations in total drift density. Results suggest that the post-spray increases resulted from the increased discharge rather than glyphosate contamination.

Date (Sept. 1984)	5	6	6	7	11	12	13	14	15	15
Collection time	pm	am	pm	am	pm	pm	am	pm	am	pm
					No. per 10 m³					
C-Creek			*					*		
Baetis sp.	15.5	11.4	12.2	2.5	2.9	0.4	0	2.2	0	0
Paraleptophlebia sp.	2.0	1.4	21.9	1.2	1.1	0.0	0.0	2.2	0.0	0.0
Amphinemeura sp.	4.0	4.3	2.4	1.2	0.7	0.4	0	0	0	0.4
Capnia sp.	1.3	4.3	4.9	0	0.7	0.8	0	4.3	0	0.2
Limnephilidae	2.7	1.4	0	2.5	0	1.3	0	0	0	1.9
1600-Tributary								†		
Paraleptophlebia sp.	0.9	0	0.9	0	0.7	0.7	0	0.8	0	7.4
Amphinemeura sp.	0.9	0.9	2.0	0	0.7	0	0	0.8	0	0.9
Limnephilidae	8.2	10.4	6.1	7.5	3.0	3.0	2.6	1.5	0.9	4.8
Chironomidae	7.1	1.7	1.0	2.8	3.5	3.0	1.3	1.5	0.9	3.3
Gammarus sp.	7.1	6.0	2.7	4.7	3.8	7.5	4.0	12.4	3.0	18.2
B-Weir (collector of treated areas)										
Baetis sp.	19.4	24.2	21.4	16.9	35.4	38.5	4.3	42.6	3.6	9.4
Paraleptophlebia sp.	3.6	4.4	1.0	1.6	1.4	1.9	0	0.5	0.3	15.5
Alloperla sp.	1.5	1.9	0.5	0.5	1.9	2.7	0.1	3.4	0	1.9
Amphinemeura sp.	3.8	1.1	1.6	1.3	0.2	1.4	0	0.5	0	1.9
Capnia sp.	5.2	2.0	3.6	2.9	7.4	8.1	1.4	11.8	0.3	6.4
Lepidostoma sp.	43.7	12.7	8.6	1.9	0.5	8.4	1.6	1.0	0.3	19.6
Limnephilidae	2.6	2.3	1.4	0.8	0.7	1.4	2.2	0.5	0.3	5.4
Chironomidae	6.5	2.5	4.2	2.4	1.4	6.1	1.4	2.4	0.5	7.8
Dixidae	1.4	1.3	0.4	0.8	0	0.5	0.3	0.5	0	6.4
Simuliidae	1.2	1.1	3.6	1.1	0.9	0.4	0.5	1.0	0.3	0.3

*Time of glyphosate application.

(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)
Publ. No. A-17

PAYNE, N.J.; Feng, J.; Reynolds, P.E. Off-target deposits and buffer zones required around water for various aerial silvicultural glyphosate applications. 1984–87. **Objectives:** To quantify airborne glyphosate and off-target deposits on foliar and water surfaces downwind of various silvicultural glyphosate use strategies, and to estimate the buffer required around water bodies to protect fish and their food supplies from direct toxicological effects. **Methods:** Three rotary-wing use strategies employing the Microfoil boom (trial 1), Thru Valve boom (2), and D8-46 (3) Hydraulic nozzle dispersal systems, were tested in drift trials on the Skeena River floodplain, B.C. (129 23 W, 54 19 N). Roundup® was diluted with water and applied at a.i. of 2.1 kg/ha using volume application rates of 230, 91, and 90 L/ha, respectively; swath widths were 13, 15, and 15 m, airspeeds were 11, 20, and 20 m/s and spray cloud volume median diameters at release were 3000, 1000, and 460 μm. The cloud release height was 3 m above canopy height (10–17 m). The canopy comprised red alder, black cottonwood, and Bebb's willow. Airborne glyphosate and off-target deposits on foliage and ground sheets were measured at various downwind distances between 25 and 200 m from multiple overlaid crosswind swaths. Airborne glyphosate and foliar deposits were measured at 2 m above ground level and at canopy top. Meteorological conditions during the trials included light winds (1 m/s at 22 m above ground level), a stable boundary layer and weak turbulence. The buffer zone width required around water bodies to protect fish and their food supply from direct toxicological effects was estimated as follows. Glyphosate deposits on ground sheets at various downwind distances from a single swath were used in a swath overlap model to calculate expected deposits on water bodies from an operational multiple swath application of 100 ha (1 x 1 km) at a glyphosate application rate of 2.1 kg/ha (upper limit for Canadian forestry). The deposit resulting from swath displacement or large drop drift was also calculated with a ballistic model. Glyphosate concentrations in various water depths were then calculated from predicted deposits, and used to estimate toxicological effects on populations of rainbow trout and *Daphnia magna* in water bodies at various downwind distances from the treatment area. Buffer widths were estimated from the downwind distances at which these toxicological effects became small. **Results and Conclusions:** The least and greatest airborne glyphosate and off-target deposits resulted from the Microfoil boom and D8-46 use strategies, respectively. For example, at a downwind distance of 50 m from a single crosswind swath the airborne glyphosate from trials 1, 2, and 3 were 380, 1960, and 13 400 μg/m^2, whereas glyphosate deposits on foliage were 0.95, 9.5, and 46 μg/m^2, and on water surfaces were 1.6, 24, and 2400 μg/m^2. A buffer width of less than 25 m from the furthest downwind flight line was required to prevent glyphosate concentrations caused by drift from 100 ha applications with the Microfoil and Thru Valve boom applications exceeding 0.3 mg/L, whereas for the D8-46 application a 30-m buffer was required. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. A-19

PITT, D.G.; Reynolds, P.E.; Roden, M.J. Crop tolerance and herbicide efficacy after site prep with liquid and dry-flowable hexazinone formulations. 1987-P. **Objectives:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 40% red/black spruce, 40% balsam fir, and 20% aspen was clearcut in February 1986 and the site prepared with a Letourneau crusher the summer of 1986. Treatment with hexazinone took place June 23 and 25, 1987, and the site was planted with multipot black spruce in early August 1987 and 1988. Raspberry, fireweed, and grass were the major competitors on the site at the time of treatment. ***Soils*** — Fine-textured, ranging from loams to gravelly silt loams and gravelly clay loams. Duff layer varies from 1 to 10 cm. CEC and pH range from 16.9 to 30.4 and 4.1 to 5.4, respectively. Site is on a gentle, east-facing slope. ***Application Specifications*** — Velpar® L was applied with a Bell 206b helicopter, equipped with a Simplex boom and D10-45 nozzles. Velpar® ULW was applied with a modified Simplex seeder, slung from the same aircraft. An active rate of 2 kg/ha was used for both herbicides and, in the case of the liquid, carried in a total volume of 55 L/ha. Weather conditions were similar for both applications; light overcast, no wind, and temperatures between 13 and 18 C. Both applications were followed by at least 11 mm of rainfall within 24 hours. ***Experimental Design*** — Completely randomized layout of 1-ha treatment plots, with 4 replications of each treatment, and 48 subsamples in each replication. ***Measurements Taken*** — June and August 1987, and August 1988. Percent cover and health of raspberry, fireweed, and grass within a 1-m radius of 48 crop-tree planting locations in each replication. Health, height, and root-collar diameter of these 48 crop trees per replication were recorded at the time of planting. **Results**:

Percent Cover of Weeds

	Raspberry			Fireweed			Grass		
Treatment	pre-treat.	2 mo. post	14 mo post	pre-treat.	2 mo. post	14 mo. post	pre-treat.	2 mo. post	14 mo. post
Untreated	11.3^{a}	23.6^{a}	48.8^{a}	0.9^{a}	2.8^{a}	8.5^{a}	3.6^{a}	5.3^{a}	10.2^{a}
Velpar® L	15.4^{a}	4.2^{b}	11.2^{b}	1.3^{a}	0.0^{b}	1.2^{b}	5.1^{a}	2.0^{b}	11.6^{a}
Velpar® ULW	13.8^{a}	6.4^{b}	14.2^{b}	1.2^{a}	0.6^{c}	3.8^{b}	4.5^{a}	3.6^{ab}	11.2^{a}
F-Value	1.00	39.11	38.86	0.58	205.4	20.66	1.01	6.54	0.08
P > *F*	.4037	.0001	.0001	.5820	.0001	.0004	.4008	.0176	.921

[a,b]Treatment differences – Bonferroni with EW error at 5%.

Frequency of Crop Trees in Each Health Class
(1 growing season after planting)

Treatment	Vigorous	Healthy	Mediocre	Moribund	Dead	Chi-squared*
Untreated	33	49	3	0	1	12.290
Velpar® L	39	46	7	1	3	(0.10<P<0.25)
Velpar® ULW		48	35	8	0	5

*Test of independence with 8 degrees of freedom.

Conclusions: Both formulations provide good control of raspberry and fireweed through two growing seasons after application. Treatment-related health problems could not be detected after one growing season in black spruce container stock that was planted 2 months after treatment. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. B-8

PITT, D.G; Reynolds, P.E.; Roden, M.J. Growth and tolerance of white spruce after site preparation with liquid hexazinone. 1984-P. **Objectives:** To generate weed efficacy and crop tolerance data for silvicultural purposes and to demonstrate potential crop growth response to the treatments. **Location:** St. Leonard, New Brunswick **Methods:** ***Site History*** — Harvested during the winter of 1981, treated with hexazinone (Velpar® L) May 19, 1984, site prepared with a Letourneau crusher in April 1985 (including controls), and planted with 2+2 bareroot white spruce in May 1985. ***Soils*** — Loams, with a 1.5- to 4.5-cm duff layer. CEC and pH range from 10.6 to 13.1 and 3.7 to 4.3, respectively. ***Application Specifications*** — Ayers Turbo Thrush aircraft, equipped with conventional boom and whirljet nozzles, flying at 193 km/h and 17 m. Hexazinone a.i. rates of 2, 3, and 4 kg/ha in water at 93.2 L/ha. Treatment plot sizes were 445 × 84 m, with two replications of each treatment. Weather at time of application was clear, 10°C, 50% RH, with winds 3–5 km/h. Rainfall was 2.5 mm 2 days before application, 2 mm 1 and 2 days after application, and 27 mm 5 days after application. ***Measurements Taken*** — August 1987. Crop height, height increment (back to the time of planting), root-collar diameter, and health of 300 randomly selected trees. Percentage cover of fireweed, raspberry, and grass within a 1-m radius of each crop tree measured. **Results:**

	Percentage Cover of Weeds			Status of Crop 3 Years After Planting				
Treatment	Raspberry	Fireweed	Grass.	Health[*]	Ht (cm)	Ht. incr. (cm)	RCD (cm)	Sample (no.)
Untreated	75.3[a]	13.3[a]	14.1[ab]	33[a]	44.0[a]	6.7[a]	1.1[a]	(150)
2 kg	15.3[b]	29.6[b]	22.6[b]	16[b]	57.7[b]	15.2[b]	1.4[b]	(50)
3 kg	15.7[b]	32.9[b]	10.7[a]	18[b]	54.9[b]	13.7[b]	1.4[b]	(50)
4 kg	15.8[b]	44.5[c]	18.9[ab]	13[b]	57.0[b]	15.9[b]	1.5[b]	(50)
F-Value	164.3	29.3	4.5	24.8	17.1	27.5	19.1	
P >*F*	0.0000	0.0001	0.0047	0.0001	0.0001	0.0001	0.0001	

[*] Evaluated from 0 (healthy) to 100 (dead).

[a,b] Treatment differences — Tukey-Kramer with EW error at 5%.

Conclusions: Hexazinone site-preparation treatment (a.i. at 2 kg/ha) was successful in enhancing white spruce growth and health through the reduction of raspberry competition and the stimulation of fireweed. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

PITT, D.G.; Reynolds, P.E.; Roden, M.J. Weed efficacy after site preparation with liquid and dry-flowable hexazinone formulations. 1987-P. Objective: To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 40% red/black spruce, 40% balsam fir, and 20% aspen was clearcut in February 1986 and the site prepared with a Letourneau crusher the summer of 1986. Treatment with hexazinone took place June 23 and 25, 1987, and half of the site was planted with multipot black spruce in early August 1987. The other half of the site was planted with similar stock in August 1988 Raspberry, fireweed, and grass were the major competitors on the site at the time of treatment. ***Soils*** — Fine textured, ranging from loams to gravelly silt loams and gravelly clay loams. Duff layer varies from 1 to 10 cm. CEC and pH range from 16.9 to 30.4 and 4.1 to 5.4, respectively. Site is on a gentle east-facing slope. ***Application Specifications*** — Velpar® L was applied with a Bell 206b helicopter equipped with a Simplex boom and D10-45 nozzles. Velpar® ULW was applied with a modified Simplex seeder slung from the same aircraft. An active rate of 2 kg/ha was used for both herbicides and, in the case of the liquid, carried in a total volume of 55 L/ha. Weather conditions were similar for both applications; light overcast, no wind and temperatures between 13 and 18°C. Both applications were followed by at least 11 mm of rainfall within 24 hours. ***Experimental Design*** — Completely randomized layout of 1-ha treatment plots with 4 replications of each treatment and 48 subsamples in each replication. ***Measurements Taken*** — June 20 and August 13–16, 1987. Percentage cover and health of raspberry, fireweed, and grass within a 1-m radius of 48 crop-tree planting locations in each replication. Health, height, and root-collar diameter of these 48 crop trees per replication were recorded at the time of planting. **Results:**

	Raspberry			Fireweed			Grass		
Treatment	pre		post	pre		post	pre		post
				Percentage Cover					
Untreated	11.2^{a}	**	23.6^{a}	0.9^{a}	**	2.8^{a}	3.6^{a}	**	5.3^{a}
Velpar® L	15.4^{a}	**	4.2^{b}	1.3^{a}	**	0.03^{b}	5.1^{a}	**	2.0^{b}
Velpar® ULW	13.8^{a}	**	6.4^{b}	1.2^{a}	**	0.6^{c}	4.5^{a}		3.6^{ab}
F-Value	1.00		39.11	0.58		205.4	1.01		6.54
$P > F$	0.4037		0.0001	0.5820		0.0001	0.4008		0.0176
				Health Value*					
Untreated	0.4^{a}		0.8^{a}	1.2^{a}		5.4^{a}	0.3^{a}		2.8^{a}
Velpar® L	0.3^{a}	**	64.3^{b}	1.8^{a}	**	97.2^{b}	2.3^{a}	**	88.6^{b}
Velpar® ULW	0.2^{a}	**	49.8^{c}	1.6^{a}	**	63.2^{c}	0.2^{a}	**	78.8^{b}
F-Value	0.49		112.57	0.51		73.02	4.69		253.27
$P > F$	0.6287		0.0001	0.6183		0.0001	0.0403		0.0001

*Evaluated from 0 (healthy) to 100 (dead).

**Differences between pre- and post-treatment (paired comparison with Student's t at 10%)

^{a,b}Treatment differences — Bonferroni with EW error at 5%.

Conclusions: First-season results indicate that both hexazinone formulations effectively controlled raspberry, fireweed, and grass, and suggest that Velpar® L was slightly more effective than Velpar® ULW. Crop tolerance data will be presented as it becomes available. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

PRASAD, R. Effect of glyphosate and ammonium sulphate on brush control. 1987. **Location:** Thessalon, Ontario. **Methods:** ***Plot Size*** — 40 m^2. ***Replicates*** — One. ***At Application*** — Date — August 21, 1987. ***Weather*** — Sunny, 23°C. ***Soil*** — Sandy loam. ***Weed Stage*** — Trembling aspen 1.0–2.3 m in height. ***Volume of Dosage*** — 180 L/ha. ***Pressure*** — 175 kPa. ***Date of Evaluation*** — September 10, 1987.

Treatment	Rate/ha kg active ingredient	Water (L/ha)	% Brush control
Control	0	0	0
Ammonium sulphate	2.5 kg prod.	180	2
Glyphosate	0.5	180	19
Glyphosate + amm. sulph.	0.5 + 2.5 kg prod.	180	24

Results: This preliminary trial suggest the possibility of some enhancement of brush control by adding ammonium sulphate to glyphosate. Additional testing, using different concentrations and different brush species, is currently being undertaken to fully assess the potential of ammonium sulphate as a glyphosate adjuvant. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-45

PRASAD, R. Effects on brush control from the addition of various adjuvants to glyphosate; Part I. Effects at high concentration of glyphosate (1.1 kg/ha). 1986–88. **Location:** Iron Bridge, Ontario. **Methods:** ***Experimental Design*** — Randomized block layout with buffer zones. ***Plot Size*** — 36 m^2. ***Replicates*** — Three. ***At Application*** — Date — August 3, 1987. ***Weather*** — Sunny, 28°C. ***Soil*** — Sandy loam. ***Weed Stage*** — Trembling aspen at 1.5–3.0 m in height. ***Volume of Dosage*** — 180 L/ha. ***Pressure*** — 175 kPa. ***Date of Evaluation*** — August 24, 1988.

Treatment	Rate/ha kg active ingredient	% Brush control
Control	0	0
Glyphosate	1.1	57
Glyphosate + Enhance	1.1 + 0.5% v/v	59
Glyphosate + Ethokem	1.1 + 0.5% v/v	58
Glyphosate + Frigate	1.1 + 0.5% v/v	55
Glyphosate + LI-700	1.1 + 0.25% v/v	54
Glyphosate + LI-700	1.1 + 0.5% v/v	53
Glyphosate + Triton	1.1 + 0.5% v/v	57
Glyphosate + Tween-20	1.1 + 0.5% v/v	59

Results: These data were derived from plots treated with glyphosate (1.1 kg/ha) and adjuvants (0.5% v/v) after 1 year. By this time glyphosate has fully translocated and produced its maximum efficacy. Effects on resprouting are also fully expressed. Even though the last year data showed some positive effects of adjuvants in efficacy enhancement of glyphosate, the 2nd-year data do not exhibit any significant difference. The formulation of glyphosate probably contains adequate amounts of various adjuvants. However, it is noteworthy that the volume rate of application was 180 L/ha. The effects of adjuvants might become more pronounced when volume rates are increased. No adverse effects on crop species (red pine) were noted. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-46

PRASAD, R. Effects on brush control from the addition of various adjuvants to glyphosate; Part II. Effects at low concentration of glyphosate (0.25 kg/ha). 1986–88. Location: Iron Bridge, Ontario. **Methods:** ***Experimental Design*** — Randomized block layout with buffer zones. ***Plot Size*** — 36 m^2. ***Replicates*** — Three. ***At Application*** — Date — August 3, 1987. ***Weather*** — Sunny, 28°C. ***Soil*** — Sandy loam. ***Weed Stage*** — Trembling aspen at 1.5–3.0 m in height. ***Volume of Dosage*** — 180 L/ha. ***Pressure*** — 175 kPa. ***Date of Evaluation*** — August 24, 1988.

Treatment	Rate/ha kg active ingredient	% Brush control
Control	0	0
Glyphosate	0.25 kg	20
Glyphosate + Enhance	0.25 + 0.5% v/v	27
Glyphosate + Ethokem	0.25 + 0.5% v/v	39
Glyphosate + Frigate	0.25 + 0.5% v/v	21
Glyphosate + LI-700	0.25 + 0.25% v/v	15
Glyphosate + LI-700	0.25 + 0.5% v/v	16
Glyphosate + Triton	0.25 + 0.5% v/v	31
Glyphosate + Tween-20	0.25 + 0.5% v/v	42

Results: One year after the treatment, the results suggest that some adjuvants (Ethokem, Triton-XR, and Tween-20) may have beneficial effects in augmenting the effectiveness of glyphosate (0.25 kg/ha), but because the magnitude of brush control is low (20%) such a low concentration of glyphosate cannot be operationally used. Interestingly, Ethokem and Tween-20 almost double the rate of efficacy of glyphosate at such low concentration. Ethokem is known for its rainfastness properties and may have influenced retention, penetration, and translocation of glyphosate.Further experiments are in progress to test this. No adverse effects were noted on crop species (red pine). **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-46

PRASAD, R. Effects on brush control from the addition of various adjuvants to glyphosate; Part III. Effects at low volume rate (30 L/ha) of application. 1986–88. **Location:** Iron Bridge, Ontario. **Methods:** ***Experimental Design*** — Randomized block layout with buffer zones. ***Plot Size*** — 36 m^2. ***Replicates*** — Three. ***At Application*** — Date — August 3, 1988 ***Weather*** — Sunny, 28°C. ***Soil*** — Sandy loam. ***Weed Stage*** — Trembling aspen at 1.5–3.0 m in height. ***Volume of Dosage*** — 30 L/ha. ***Pressure*** — 0, CDA (HERBI). ***Date of Evaluation*** — August 24, 1988.

Treatment	Rate/ha kg active ingredient	% Brush control
Control	0	0
Glyphosate	0.35	15
Glyphosate + Enhance	0.35 + 0.5% v/v	14
Glyphosate + Ethokem	0.35 + 0.5% v/v	16
Glyphosate + Frigate	0.35 + 0.5% v/v	18
Glyphosate + Triton-XR	0.35 + 0.5% v/v	17

Results: These preliminary findings suggest that Enhance, Ethokem, Frigate, and Triton are not promising potential adjuvants for use with glyphosate in controlling brush at very low volume rates of application. Probably at low volume rates, there are adequate amounts of adjuvants in the formulation of Vision. Further testing is required. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-46

PRASAD, R. Enhanced growth of red pine following competition control by hexazinone. 1983–85. **Objectives:** Effects of spotgun treatment of hexazinone were examined for 3 years on weed control and conifer release in a red pine plantation in northern Ontario. **Results:** Soil treatment with hexazinone (2 mL of a 1.6 kg/ha concentration) proved effective in controlling aspen, pincherry, and white birch with competition release resulting in enhanced growth of 10-year-old red pines. Growth response measured in terms of increased basal diameter and height of trees yielded differences between treated and control plots. Even though gain in height was slower (about 31%) in the treated plots as opposed to untreated, the increment in basal diameter of trees from the treated plots was much greater (over 50%) than those from the control plots. **Conclusions:** Competition release by chemical herbicides had beneficial effects on growth, development, and yield of red pines. Competition control may result in diversion of resources to conifer crop. Whether greater availability of nutrients, moisture, and light contributed to accelerated growth of red pines must be investigated. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

PRASAD, R. Evaluation of some herbicides for weed control in red pine plantations. 1982–85. **Location:** Six herbicides and a handcutting method were used to investigate control of weeds (eastern alders, aspen, and grasses) in a 5-year-old red pine plantation in Algoma district of northern Ontario (Searchmont and Thessalon). **Methods:** A field experiment with randomized block layout and with three replications (plot size, 5x5 m) was designed. Some herbicides (Garlon®, glyphosate, 2,4-D) were applied to foliage by a knapsack sprayer and some others (Velpar®, Herbecq®-20, and Spike®-80W) were applied to soil. Treatments were made in mid-August 1982 when conifer needles were completely "hardened off." Observations on phytotoxicity and weed control were made in the following year and August 1984. **Results:** Garlon®, Roundup®, Herbec®-20, and Spike®-80W were most effective against aspen while 2,4-D, Roundup®, Garlon®, and Spike®-80W were effective against eastern alder. Grasses were best controlled by Roundup®, Spike®-80W, and Velpar®. However, both Herbec®-20 and Spike®-80W were extremely phytotoxic to red pine and seemed more suited for site preparation. Even though Herbec®-20 was very efficacious against aspen, it did not completely kill the alders. Profuse coppicing of alder stumps was visible in plots cut manually; similarly, aspen resprouted heavily in plots cut manually, and resprouting was more frequent in plots treated with 2,4-D and Garlon® than with other herbicides.

Treatment	Rate (per ha)	Method of treatment	% Weed control			% Crop tolerance
			alder	aspen	grass	
Control	–	–	0*	0	0	100
2,4-D Amine	6 L	F.S.*	74.4	81.1	0	100
Garlon®	6.5 L	F.S.	81.1	96.7	0	100
Roundup®	5 L	F.S.	100	98.6	63.3	100
Herbec®-20	14 kg	S.A.*	0	98.5	44.4	0
Spike®-80W	8 kg	S.A.	96.7	100	58.9	0
Velpar®	10 L	S.A.	18.9	98.7	52.2	100
Manual cut	–	–	60.5	76.	0	100

*F.S. = Foliar Spray; S.A. = Soil Application.
0 = no control and/or tolerance; 100 = complete control and/or tolerance.

Treatment	Rate (per ha)	Method of treatment	No. of resprouts	
			alder	aspen
Control	–	–	0	0
2,4-D Amine	6 L	F.S.*	150	18.3
Garlon®	6.5 L	F.S.	35	25.3
Roundup®	5 L	F.S.	0	11
Herbec®-20	14 kg	S.A.*	0	12
Spike®-80W	8 kg	S.A.	6.7	0
Velpar®	10 L	S.A.	6.7	2.7
Manual cut	–	–	235	41.3

*F.S. = Foliar Spray; S.A. = Soil Application.

Garlon®, Roundup®, and Velpar® seem promising for weed control in red pine plantations. Red pine seems more resistant to Velpar® than jackpine and further experiments are underway to study the causes of this selectivity. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-27, C-29, C-36

PRASAD, R. O. Translocation of glyphosate in forest weeds. 1985. **Objective:** Glyphosate (Roundup®) was recently registered for forestry uses (site preparation and conifer release) in Canada and is very effective in controlling many perennial weeds such as aspen, alder, and birches. However, resprouting is a serious problem with many of these perennial forest weeds and therefore a translocatable (phloem-mobile) herbicide would be rated as an efficient compound. Considerable research has been done with agricultural weeds, but very little information is available on the penetration, distribution, and accumulation of glyphosate in forest weeds. **Methods:** With this in mind, a greenhouse study was carried out to study the translocation profiles of glyphosate-C14 in two forest weeds (eastern alder and white birch). Plants were grown in the greenhouse under controlled conditions of light intensity, temperature, relative humidity, and nutrition for 4 months and a single and fully developed leaf of each species was fed with glyphosate-C14 (1200 ppm) and glyphosate-C14 (1200 ppm) plus an adjuvant (G3780A, 0.05%). There were three replications and after 2 weeks of feeding, plants were harvested; separated into leaf, stem, and roots; and counted for the radioactivity. While the radioactivity was extracted from these plant parts by a standard procedure, a gross autoradiographic study was also carried out to monitor the path of translocation in different plant parts.

Weed species	Treatment	Content of radioactivity (cpm/g)			Total (cpm/g)
		Leaves	Stem	Roots	
Alder	a) Glyphosate alone	601	817	225	1643
	b) Glyphosate + adjuvant	883	1367	330	2580
White birch	a) Glyphosate alone	1617	10	375	2002
	b) Glyphosate + adjuvant	2008	167	450	2625

Results: Both qualitative and quantitative techniques demonstrate that glyphosate is highly phloem-mobile in alder and white birch and that accumulation takes place in leaves, stems, and roots. The adjuvant was very effective in increasing the penetration and as a result greater amounts of glyphosate moved into the roots. These results suggest that glyphosate is an efficacious herbicide for perennial weeds due to its capacity to translocate and accumulate into roots of forest weeds. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-30, C-38

PRASAD, R.; Cadogan, L. Role of droplet size and density in relation to efficacy of forest herbicides. 1986–88. Considerable controversy exists regarding droplet size, volume, and dosage rates of herbicides on efficacy. Some believe that smaller droplets are more potent than larger ones while others hold the opposite view. All commercial nozzles emit a spectrum of droplet sizes including smaller and larger droplets and it is, therefore, difficult to define the role of either size droplets on efficacy. Research on droplet behavior is needed for optimizing the uses of herbicides and thereby reducing the costs of applications. This is particularly true with forest herbicides (triclopyr, glyphosate, and hexazinone) which are more expensive than the traditional herbicide, 2,4-D. **Objective:** To monitor the role of uniform and precise droplet sizes produced by a monosize droplet generator on efficacy of above herbicides using forest weeds. **Methods:** A controlled greenhouse study using 4-month-old seedlings of aspen, alder, and white birch grown under constant conditions of light temperature, relative humidity, and nutrition was carried out. ***Application Specifications*** — A monosize droplet generator was used to deposit droplets (155, 335, 465, and 665 μm) of uniform sizes on a single leaf by keeping the volume and dosage of herbicides constant. A 2-μL solution of each herbicide (triclopyr, glyphosate, and hexazinone at 2 kg/80 L/ha) together with 0.1% rhodamine dye was prepared and then homogeneous droplets of above sizes of each herbicide were applied on the third leaf. Evaluations of necrosis, epinasty, bleaching, and phytotoxicity were carried out after 3 weeks by a standard procedure both on the individually treated leaves and on the untreated (translocated) parts. Treatments were replicated and some experiments were repeated. **Results:** In general, small droplets (155–355 μm) of each herbicide were more efficacious than large droplets (665 μm) probably because of greater coverage of the target areas as well as greater penetration and translocation of the materials. Large size droplets tended to cause localized injury and thereby impeded the movement of herbicides. Some interactions between herbicide types, concentration of droplet size, and plant species were also observed. The implication of these findings in relation to dosage, volume rates, and adjuvant mixtures would be discussed. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-33, C-42, C-43

PRASAD, R.; Feng, J.C. Red pine release and residue persistence after hexazinone spotguntreatment in Northern Ontario. 1983–87. (In 1989 accepted by Weed Technol.) **Objectives:** To evaluate weed control and red pine release from spotgun treatment with hexazinone and to monitor residue persistence and lateral movement in the sandy loam soil. **Location:** Parkinson Township, Blind River District of northern Ontario (Great Lakes/St. Lawrence Forest Region). **Methods:** The study site was a 10-ha red pine plantation planted in 1974. In 1983, the year of the proposed trial, seedling growth was being suppressed by clones of aspen, intermixed with a few white birch and pin cherry. These species were about 2–3 m high compared with 1.5 m for red pine seedlings. Velpar® L was applied at 2 mL (480 mg hexazinone) per spot, in a grid-pattern (1.83 × 1.83 m) approximating a 1.64 kg/ha a.i. treatment. Five replicate plots of 10 × 10 m were laid out for evaluating weed control and conifer release (monitored for 3 years). A second set of five plots, located within the plantation but outside the treatment area, were to act as controls. Six quadrats (1.83 × 1.83 m), near the perimeter of the treatment area, were designated as soil sampling stations to monitor residues from individual hexazinone spots. Treatment was conducted on July 30, 1983. The treatment procedure involved applying spots at the base of competing brush trees, midway between rows and columns of planted red pine seedlings. These spray locations represent the safest distance from each set of four surrounding crop seedlings within the plantation's grid-pattern. Spots were only applied when competing aspen were present. To accommodate the soil residue experiment, a single 2-mL spot of liquid hexazinone (480 mg a.i.) was applied to the center of each designated soil sampling station (monitored for 1 year). An effort was made not to treat the immediate vicinity of these stations to prevent the possible interference with residues from adjacent spot applications. To study hexazinone persistence in soils, six treated spots and the soil immediately surrounding them were sampled before, immediately following, and 365 days after the treatment. Two strata of the soil column (surface dimensions of 18.5 × 18.5 cm to cover the whole treated spot) were excavated at the center of each station, one from the 0-to 15-cm depth and the second from the 15-to 30-cm depth. To study the lateral movements of hexazinone residues, core samples were taken from two depths (0-15 cm and 15-30 cm) by extracting randomly with a soil auger (5 cm diameter) at a radial surface distance of 50 cm from the treated spot. Soil samples were processed, prepared, and analyzed by gas chromatography for residues of hexazinone and its metabolites A and B. **Results:** This grid-pattern spot applications of liquid hexazinone resulted in 88% aspen stem dieback and variable control of white birch and pin cherry. The height and basal diameter of red pine increased to 131 and 150% that of control, respectively, after 3 years. One year after treatment, hexazinone in the 30-cm soil column directly beneath the treated spot was reduced to 1% of the amount applied, and was below the concentration that could cause damage to red pine, suggesting that regeneration would not be adversely affected. The appearance of small amounts of metabolites A and B (0.2 and 0.3%) indicated the noncumulative degradation of hexazinone in soils. No lateral movement of hexazinone was found 50 cm beyond treated spots. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

PRASAD, R.; Travnick, D. Evaluation of a modified sprayer for application of herbicides to small field plots. 1983–85. **Objectives:** Herbicides are one of the most economical tools for forest management (site preparation and conifer release) and yet there is a dearth of herbicides registered for forestry uses in Canada. Therefore, a new program of screening of newer compounds and/or their formulations was initiated at FPMI. This involves two steps: (i) a comprehensive laboratory and greenhouse screening trial is carried out to discover the potential activity of several promising compounds against a wide spectrum of forest weeds and (ii) when some of the selected candidates show promise, they are evaluated under field conditions using a small field plot-technique to determine the effects of dosage rates, droplet size, volume rates, formulation characteristics, and weather parameters on efficacy. **Methods:** A modified sprayer system for delivering uniform application rates to small field plots was developed and tested under field conditions near Thessalon, Ontario. The target species was predominantly aspen, 2–3 m high; and two types of plots, rectangular (square) (5 m x 5 m) and circular (2.5 m in diameter) were used. Accordingly, the sprayer was designed to suit both types of plots and consisted of a boom with nozzles, upright handles, and a pressurized handpump sprayer; the boom is made of two pieces of 1-inch aluminum pipe (each 3 m long) connected in the middle with a 3/4-inch straight coupling together with 10 flat spray, vari-spacing nozzles located on nine double-hose connectors plus one single-hose connector, all with sliding clamps; a Tygon tubing (3/8-inch) cut to length between nozzles was led from the boom to the sprayer; the boom attachment system was then mounted on two pieces of 1-inch aluminum pipe (3 m long) with a 3/4-inch single socket tee attached to each pipe to look like an H. These two upright handle pipes carried the boom (with nozzles) over the plots to be sprayed and the height of the boom was adjusted according to the size of the brush. A garden sprayer (3 gallons, 30 psi) was connected to the boom and was carried by the operator on one side of the plot while the other side was supported by an assistant on the opposite side of the plot. In the circular plot design, the spraying system used only half of the boom and was mounted on only one handle, thus up to a 2.5-m radius could be sprayed in a circular manner. The sprayer was locally assembled and was used to spray Velpar® (10 L/ha) in 150 L of water to a stand of aspen; the delivery speed was about 4 km/h and the boom was held at 40 cm above the canopy; application was made early in August 1984 and the response (weed control) was monitored 3 weeks later.

	Weed control (%)		
Plot type	Damage	Defoliation	Stem dieback
Rectangular*	80.1	73.2	5.1
Circular	91.8	95.0	13.3

*Average of three plots. 0% = no control, 100% = complete kill.

Results: A preliminary trial suggests that the sprayer system functions properly and that the degree of weed control is slightly greater in circular than in the rectangular plots, probably because of better coverage resulting from a slower speed. Further work is in progress. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. C-31, C-37

REYNOLDS, P.E.; MacKay, T.S.; McCormack, M.L., Jr. One-year results for a hexazinone conifer release trial. 1984–85. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of sugar maple, red maple, yellow birch, balsam fir, and black spruce was clearcut in 1980–81 and subsequently site-prepared with a Letourneau crusher; 2+2 bareroot black spruce were planted in May 1982. Before treatment, major forest weed competition was approximately 1 m in height and consisted of raspberry and several hardwood species. Foliar application of hexazinone (Velpar® L) took place August 29 and 31, 1984. ***Application Specifications*** — Ayers Turbo Thrush aircraft, equipped with a thru-valve-boom and conventional whirljet nozzles, flying at 201 km/h and 17 m. Hexazinone a.i. rates were 2, 3, and 4 kg/ha in water at 93.2 L/ha. Treatment plot sizes were 477 × 84 m, with two replications of each treatment. Weather at time of application was overcast to overcast with light rain, 21–25°C, 100% RH, winds 0–8 km/h. Precipitation occurred 5 days before application, then heavy rain on August 30 and no precipitation until September 4. ***Measurements Taken*** — June 1985. Weed and crop health were assessed within a 1.5-m radius of five systematically located subsamples within each treatment plot (a 25-m radius was used for brush species). **Results:**

	Treatments							
	0 kg/ha		2 kg/ha		3 kg/ha		4 kg/ha	
Species	health[a]	no.[b]	health[a]	no.[b]	health[a]	no.[b]	health[a]	no.[b]
Black spruce	0	11	0	10	7	10	16	10
Balsam fir	0	4	0	6	0	8	0	5
Raspberry	21	11	55	10	56	10	68	10
Pin cherry	8	9	61	5	32	10	80	8
Striped maple	—	0	—	0	—	0	75	2
Mountain maple	8	4	20	2	43	5	24	7
Red maple	2	9	22	10	4	10	5	10
Sugar maple	5	2	0	1	10	1	5	2

[a] Evaluated from 0 (healthy) to 100 (dead).

[b] Number of observations.

Conclusions: Foliar application of hexazinone was generally unsuccessful in controlling those forest weeds present, at all treatment rates, except for raspberry, pin cherry, and striped maple. Despite poor hardwood control, an interesting trend of control for maple species present was noted. Control was greatest for striped maple followed sequentially by mountain maple, red maple, and sugar maple. At the two higher rates, some minor injury was noted for the 2-year-old 2+2 black spruce stock. No injury was observed, at any of the rates, for naturally regenerated balsam fir present on the treated areas. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; MacKay, T.S.; McCormack, M.L., Jr. Results of a hexazinone–mechanical site preparation trial. 1984–85. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Harvested during the winter of 1981, treated with hexazinone (Velpar® L) May 19, 1984, site prepared with a Letourneau crusher in April 1985 (including controls) and planted with 2 + 2 bareroot white spruce in May 1985. ***Soils*** — Loams, with a 1.5- to 4.5-cm duff layer. CEC and pH range from 10.6 to 13.1 and 3.7 to 4.3, respectively. ***Application Specifications*** — Ayers Turbo Thrush aircraft, equipped with conventional boom and whirljet nozzles, flying at 193 km/h and 17 m. Hexazinone a.i. rates were 2, 3, and 4 kg/ha in water at 93.2 L/ha. Treatment plot sizes were 445 × 84 m, with two replications of each treatment. Weather at time of application was clear, 10°C, 50% RH, with winds 3–5 km/h. Rainfall was 2.5 mm 2 days before application, 2 mm 1 and 2 days after application, and 27 mm 5 days after application. ***Measurements Taken*** — August 1984 and September 1985. Weed efficacy and crop tolerance data were collected within a 1.5-m radius of five systematically located subsamples within each treatment plot (a 25-m radius was used for brush species). **Results:**

	Treatments							
	0 kg/ha		2 kg/ha		3 kg/ha		4 kg/ha	
Species	1984	1985	1984	1985	1984	1985	1984	1985
	Percent Control[a]							
Raspberry	0	-17	100	80	98	80	98	84
	Health Value[b]							
Elderberry	0	4	58	17	10	37	70	14
Red maple	0	36	8	47	10	40	13	52
Hazel	0	23	15	40	17	43	21	33
Mountain maple	0	43	10	10	11	64	13	49
Pin cherry	–	0	13	30	10	40	10	–
Sugar maple	–	10	10	18	18	30	10	40
Yellow birch	–	–	–	–	15	35	10	40
White spruce	–	0	–	0	–	1	–	0
Balsam fir	–	–	50	–	–	18	–	2

[a] Percent control = (pre-treat % cover – post-treat % cover)/ pre-treat % cover.

[b] Health value, evaluated from 0 (healthy) to 100 (dead).

Conclusions: The soil-applied hexazinone site-preparation treatment provided excellent control of the major weed competitor, raspberry, at the lowest rate. Crushing the chemically treated site increased raspberry cover in several of vegetation sample quadrats, demonstrating that mechanical preparation after chemical treatment exacerbates the weed problem. Other brush species (that is, northern hardwoods) were poorly controlled by hexazinone treatment alone. However, hardwoods that were chemically treated and crushed exhibited greater weed control than hardwoods that were crushed but not treated with hexazinone. Because hexazinone enhanced hardwood control beyond that obtained by crushing alone, crushing in advance of chemical treatment likely would have increased hardwood control while precluding any enhancement of the raspberry competition. No notable injury was observed for white spruce planted after crushing in 1985. By contrast, naturally regenerated balsam fir sustained notable injury following crushing. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Crop tolerance after spring soil treatment with hexazinone, sulfometuron-methyl and metsulfuron-methyl. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and the site prepared with a Letourneau crusher the summer of 1985. Herbicide treatments took place May 27–30, 1936, and 2 + 2 bareroot black spruce were planted in June 1986 and 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Fine-textured, including loams, silty loams, clay loams, silty clays, and clays. Duff layer varies from 1 to 11 cm. CEC and pH range from 6.2 to 33.5 and 3.6 to 6.2, respectively. ***Application Specifications*** — Granular hexazinone (Pronone® 10G - 1, 2, & 4 kg/ha a.i. and Pronone® 5G - 2 kg/ha a.i. was applied with a skidder-mounted OMNI blower unit. Liquid hexazinone (Velpar® L - 2 kg/ha a.i. was applied with a skidder-mounted hydraulic sprayer, equipped with a cluster nozzle, in a total volume of 364 L/ha. Sulfometuron-methyl (Oust®-150, 300, and 450 g/ha a.i.) and metsulfuron-methyl (Ally®-36 and 72 g/ha a.i.) were applied with the same liquid sprayer, in a total volume of 460 L/ha. ***Experimental Design*** — Completely randomized layout of 50 x 100 m treatment plots, with four replications of each treatment. ***Measurements Taken*** — August 1986, 1987, and 1988. Crop health, height, height-increment, and root-collar diameter for 20 trees from each planting date, within each replication. Health and percent cover of raspberry and grass from two 2-m radius subsamples within each replication. **Results:**

		Percent Mortality of Crop Trees					
Sample time	Control	Pronone®10G 1 kg	Velpar® 2 kg	Pronone®5G 2 kg	Pronone®10G 2 kg	Pronone®10G 4 kg	$P>X^2$*
1986 Trees							
June 86	0	0	0	0	0	0	–
Aug. 86	4	3	6	3	6	7	0.657
Aug. 87	13	24	18	19	27	28	0.121
Aug. 88	10	29	18	24	33	30	0.004
1987 Trees							
June 87	0	0	1	0	0	0	–
Aug. 87	1	3	3	3	0	4	0.303
Aug. 88	12	10	20	13	5	31	0.000

		Percent Mortality of Crop Trees					
Sample time	Control	Ally® 36 g	Ally® 72 g	Oust® 150 g	Oust® 300 g	Oust® 450 g	$P>X^2$*
1986 Trees							
June 86	0	0	0	0	0	0	–
Aug. 86	4	5	5	7	13	13	0.134
Aug. 87	13	15	20	17	31	34	0.003
Aug. 88	10	18	22	18	40	38	0.000
1987 Trees							
June 87	0	0	0	0	0	0	–
Aug. 87	1	3	3	0	3	1	0.676
Aug. 88	12	8	8	13	11	13	0.789

*Test of independence with 5 degrees of freedom.

Conclusions: 2 + 2 bareroot black spruce may be safely planted 1 year after hexazinone treatment, at rates less than or equal to 2 kg/ha a.i., or sulfometuron-methyl or metsulfuron-methyl treatment at all rates tested. Crop trees planted immediately after metsulfuron-methyl or sulfometuron-methyl treatment sustained notable crop injury and unacceptable mortality. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. B-17

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Herbicide efficacy and crop tolerance after fall soil treatment with liquid and granular hexazinone. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and site prepared with a Letourneau crusher the summer of 1985. Hexazinone treatment took place September 18-19, 1986, and 2 + 2 bareroot black spruce were planted in June 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Fine textured, including loams, silty loams, clay loams, silty clays, and clays. Duff layer varies from 3 to 11 cm. CEC and pH range from 6.2 to 18.9 and 3.6 to 4.9, respectively. ***Application Specifications*** — Granular hexazinone (Pronone® 10G) was applied with a skidder-mounted OMNI blower unit, at a.i. of 2 kg/ha. Liquid hexazinone (Velpar® L) was applied with a skidder-mounted hydraulic sprayer, equipped with a cluster nozzle, at a.i. of 2 kg/ha, in a total volume of 436 L/ha. ***Experimental Design*** — Completely randomized layout of 50 x 100 m treatment plots, with 5, 4, and 3 replications of each of the control, liquid, and granular treatments, respectively. ***Measurements Taken*** — August 1986; pre-treatment cover and health of raspberry and grass from two 2-m radius subsamples within each replication. June 1987; health, height, height-increment, and root-collar diameter of 20 crop trees, at the time of planting, from within each replication. August 1987 and 1988; repeat measurements of weeds and crop. **Results:**

Mean Percent Cover of Raspberry and Grass

Sample time	Control (0 kg)	Velpar® L (2 kg)	Pronone® 10G (2kg)	$P > F$
Raspberry				
pre-treatment	55.0[a]	24.4[a]	18.3[a]	0.2055
1-year post	68.5[a]	6.2[b]	12.5[b]	0.0012
2-year post	66.5[a]	18.8[a]	31.7[a]	0.0958
Grass				
pre-treatment	5.0[a]	6.9[a]	6.7[a]	0.9173
1-year post	28.0[a]	3.8[a]	5.8[a]	0.0767
2-year post	13.5[a]	10.6[a]	15.0[a]	0.9142

[a,b] Comparison by Tukey-Kramer with EW error at 5%.

Percent Mortality of Crop Trees

Sample time	Control (0 kg)	Velpar® L (2 kg)	Pronone® 10G (2kg)	$P > X^2$[*]
At planting	0	0	0	-
1st growing season	1	0	2	0.604
2nd growing season	12	20	12	0.268

[*] Test of independence with 2 degrees of freedom.

Conclusions: Under the test conditions, both liquid and granular formulations of hexazinone effectively controlled raspberry and grass for one post-treatment growing season. Liquid hexazinone controlled raspberry for two growing seasons, but control declined compared with the 1rst year after treatment. Neither formulation controlled grass for more than one growing season. At present, it appears that 2 + 2 black spruce may be safely planted immediately after fall hexazinone treatment (either formulation) at rates that do not exceed a.i. of 2 kg/ha. Further monitoring of crop tolerance is warranted. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. B-18

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Herbicide efficacy and crop tolerance after summer foliar treatment with sulfometuron-methyl and metsulfuron-methyl. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and site prepared with a Letourneau crusher the summer of 1985. Herbicide treatments took place August 15, 1986, and 2+2 bareroot black spruce were planted in June 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Primarily silty-clay loams and silty clays, with a 1- to 10-cm duff layer. CEC and pH range from 8.4 to 33.5 and 3.8 to 6.2, respectively. ***Application Specifications*** — Both herbicides were applied with a skidder-mounted hydraulic sprayer equipped with a cluster nozzle; Ally® at a.i. of 36 and 72 g/ha, Oust® at a.i. of 150 and 300 g/ha, all in 447 L of water/ha. ***Experimental Design*** — Completely randomized layout of 25 x 50 m treatment plots, with 5 replications of the control plots and 4 replications of each of the treatments. ***Measurements Taken*** — August 1986; pre-treatment cover and health of raspberry and grass from one 2-m radius subsample within each replication; health of brush species from a 5-m radius subsample within each replication. June 1987; health, height, height-increment, and root-collar diameter of 20 crop trees, at the time of planting, from within each replication August 1987 and 1988; repeat measurements of weeds and crop. **Results:**

Mean Percent Cover of Raspberry and Grass

Sample time	Control	Ally® 36	Ally® 72	Oust® 150	Oust® 300	$P > F$
Raspberry						
pre-treatment	55.0^{a}	36.2^{a}	21.2^{a}	36.2^{a}	47.5^{a}	0.4237
1-year post	68.5^{a}	3.8^{b}	5.0^{b}	11.2^{b}	5.0^{b}	0.0001
2-year post	66.5^{a}	35.0^{a}	31.2^{a}	47.5^{a}	20.0^{a}	0.2599
Grass						
pre-treatment	5.0^{a}	13.8^{a}	13.8^{a}	12.5^{a}	10.0^{a}	0.7271
1-year post	28.0^{a}	17.5^{a}	22.5^{a}	1.2^{a}	0.0^{a}	0.1377
2-year post	13.5^{ab}	56.2^{a}	48.8^{ab}	8.8^{ab}	3.8^{b}	0.0098

[a,b] Multiple comparison by Tukey-Kramer with EW error at 5%.

Percent Mortality of Crop Trees

Sample time	Control	Ally® 36	Ally® 72	Oust® 150	Oust® 300	$P > X^2$*
at planting	0	0	0	1	0	–
1st growing seas.	1	6	6	3	9	0.063
2nd growing seas.	12	40	16	19	38	0.000

*Test of independence with 4 degrees of freedom.

Conclusions: Under the test conditions, both herbicides controlled raspberry for one post-treatment growing season, at the rates tested. Only the higher rate of Oust® controlled raspberry for two post-treatment growing seasons. Ally® did not control grass, and appears to have promoted grass invasion of treated plots. Oust® (a.i. of 300 g/ha) and Ally® (a.i. of 36 g/ha) resulted in unacceptable levels of crop mortality in 2+2 bareroot black spruce planted the spring following August foliar treatment. Acceptable levels of crop mortality were observed for similar stock planted 1 year after spring, soil site preparation with these herbicides. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. B-19

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Weed efficacy and crop tolerance after spring soil treatment with liquid and granular hexazinone formulations. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and the site prepared with a Letourneau crusher the summer of 1985. Hexazinone treatment took place May 27–29, 1986, and 2+2 bareroot black spruce were planted in June 1986 and 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Fine-textured, including loams, silty loams, clay loams, silty clays, and clays. Duff layer varies from 3 to 11 cm. CEC and pH range from 6.2 to 18.9 and 3.6 to 4.9, respectively. ***Application Specifications*** — Granular hexazinone (Pronone® 10G) was applied with a skidder-mounted OMNI blower unit with a.i. at 1, 2, and 4 kg/ha. Pronone® 5G was applied with the same unit at a.i. of 2 kg/ha. Liquid hexazinone (Velpar® L) was applied with a skidder-mounted hydraulic sprayer, equipped with a cluster nozzle at a.i. of 2 kg/ha, in a total volume of 364 L/ha. ***Experimental Design*** — Completely randomized layout of 50 × 100 m treatment plots with four replications of each treatment. ***Measurements Taken*** — August 1986 and 1987. Crop health, height, height increment, and root-collar diameter for 20 trees from each planting date within each replication. Health and percentage cover of raspberry and grass from two 2-m radius subsamples within each replication. **Results:**

	Percentage Cover				Health* of Crop Trees, One Growing Season After Planting		
	Raspberry		Grass				
Treatment	1986	1987	1986	1987	1986 trees		1987 trees
Untreated	55.0^{a}	68.5^{a}	5.0^{a}	28.0^{a}	26^{a}		21^{a}
Velpar® L (2 kg)	3.0^{b}	4.5^{b}	1.0^{a}	3.5^{a}	34^{a}		30^{a}
Pronone® 5G (2 kg)	7.5^{b}	14.4^{b}	3.1^{a}	6.9^{a}	32^{a}		31^{a}
Pronone® 10G (2 kg)	6.5^{b}	14.4^{b}	3.0^{a}	12.0^{a}	37^{a}	**	24^{a}
Pronone® 10G (1 kg)	21.3^{ab}	26.8^{b}	6.3^{a}	18.8^{a}	31^{a}		27^{a}
Pronone® 10G (4 kg)	3.8^{b}	9.4^{b}	3.8^{a}	5.0^{a}	35^{a}		32^{a}
F-Value	36.86	12.03	0.91	2.23	0.65		1.63
$P > F$	0.0006	0.0001	0.4909	0.0897	0.6665		0.1947

*Evaluated from 0 (healthy) to 100 (dead).

**Indicates differences between planting times (Student's *t* at 10%).

^{a,b}Indicate treatment differences – Tukey-Kramer with EW error at 5%.

Conclusions: Under the test conditions both liquid and granular formulations of hexazinone (a.i. 2 kg/ha) effectively controlled raspberry and grass and caused no adverse effects to 2+2 black spruce planted shortly after treatment. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Weed efficacy and crop tolerance after spring soil treatment with sulfometuron-methyl and metsulfuron-methyl. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and the site prepared with a Letourneau crusher the summer of 1985. Herbicide treatments took place May 29–30, 1986, and 2+2 bareroot black spruce were planted in June 1986 and 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Primarily silty clay loams and silty clays with a 1- to 10-cm duff layer. CEC and pH range from 8.4 to 33.5 and 3.8 to 6.2, respectively. ***Application Specifications*** — Both herbicides were applied with a skidder-mounted hydraulic sprayer equipped with a cluster nozzle; Ally® with a.i. at 36 and 72 g/ha, Oust® with a.i. at 150, 300, and 450 g/ha, all in water at 460 L/ha. ***Experimental Design*** — Completely randomized layout of 25 × 50 m treatment plots with four replications of each treatment. ***Measurements Taken*** — August 1986 and 1987. Crop health, height, height increment, and root-collar diameter for 20 trees from each planting date within each replication. Health and percentage cover of raspberry and grass from one 2-m radius subsample within each replication. **Results:**

	Percentage Cover						
	Raspberry		Grass		Health* of Crop Trees, One Growing Season After Planting		
Treatment	1986	1987	1986	1987	1986 trees		1987 trees
Untreated	55.0^{a}	68.5^{a}	5.0^{a}	28.0^{a}	26^{a}		21^{a}
Ally® (36 g)	5.0^{b}	26.2^{b}	1.2^{a}	10.0^{ab}	40^{b}	**	28^{a}
Ally® (72 g)	3.8^{b}	15.0^{b}	5.0^{a}	8.8a^{b}	47^{b}		35^{a}
Oust® (150 g)	11.2^{b}	25.0^{b}	3.8^{a}	5.0a^{b}	43^{b}	**	25^{a}
Oust® (300 g)	7.5^{b}	3.5^{b}	1.2^{a}	1.2^{b}	51^{b}	**	29^{a}
Oust® (450 g)	2.5^{b}	6.2^{b}	0.0^{a}	0.0^{b}	50^{b}	**	28^{a}
F-Value	6.49	13.16	1.45	3.82	12.46		1.38
$P>F$	0.001	0.0001	0.2523	0.0146	0.0001		0.2760

*Evaluated from 0 (healthy) to 100 (dead).

**Indicates differences between planting times (Student's t at 10%).

[a,b] Indicate treatment differences – Tukey-Kramer with EW error at 5%.

Conclusions: Under the test conditions, both herbicides effectively controlled raspberry and grass (Ally® with a.i. at 72 g/ha and Oust® with a.i. at 300 g/ha) and caused injury to 2+2 black spruce planted shortly after treatment. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Weed efficacy and crop tolerance after fall soil treatment with liquid and granular hexazinone. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods**: ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and the site prepared with a Letourneau crusher the summer of 1985. Hexazinone treatment took place September 18–19, 1986, and 2+2 bareroot black spruce were planted in June 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Fine textured, including loams, silty loams, clay loams, silty clays, and clays. Duff layer varies from 3 to 11 cm. CEC and pH range from 6.2 to 18.9 and 3.6 to 4.9, respectively. ***Application Specifications*** — Granular hexazinone (Pronone® 10G) was applied with a skidder-mounted OMNI blower unit with a.i. at 2 kg/ha. Liquid hexazinone (Velpar® L) was applied with a skidder-mounted hydraulic sprayer equipped with a cluster nozzle, with a.i. at 2 kg/ha in a total volume of 436 L/ha. ***Experimental Design*** — Completely randomized layout of 50 × 100 m treatment plots with five, four, and three replications of each of the control, liquid, and granular treatments, respectively. ***Measurements Taken*** — August 1986; pre-treatment cover and health of raspberry and grass from two 2-m radius subsamples within each replication. June 1987; health, height, height increment, and root-collar diameter of 20 crop trees at the time of planting from within each replication. August 1987; repeat measurements of weeds and crop. **Results:**

	Percentage Cover				Health* of Crop Trees		
	Raspberry		Grass		At Planting		+ 1 Season
Treatment	pre	post	pre	post	June 1987		August 1987
Untreated	55.0^{a}	68.5^{a}	5.0^{a}**	28.0^{a}	27^{a}	**	21^{a}
Velpar® L (2 kg)	24.4^{a}	6.3^{b}	6.9^{a}	3.8^{a}	27^{a}		24^{a}
Pronone® 10G(2 kg)	18.3^{a}	12.5^{b}	6.7^{a}	5.8^{a}	29^{a}		25^{a}
F-Value	1.90	15.43	0.09	3.46	0.09		1.23
$P > F$	0.2055	0.0012	0.9173	0.0767	0.9147		0.3417

*Evaluated from 0 (healthy) to 100 (dead).

**Indicates differences between sample times (paired comparison with Student's *t* at 10%).

^{a,b}Indicate treatment differences – Tukey-Kramer with EW error at 5%.

Conclusions: Under the test conditions both liquid and granular formulations of hexazinone effectively controlled raspberry and grass and caused no adverse effects to 2+2 black spruce planted the spring following fall treatment. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Weed efficacy and crop tolerance after summer foliar treatment with sulfometuron-methyl and metsulfuron-methyl. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Methods: *Location*** — St. Leonard, New Brunswick. ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and the site prepared with a Letourneau crusher in summer 1985. Herbicide treatments took place August 15, 1986, and 2+2 bareroot black spruce were planted in June 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Primarily silty clay loams and silty clays, with a 1- to 10-cm duff layer. CEC and pH range from 8.4 to 33.5 and 3.8 to 6.2, respectively. ***Application Specifications*** — Both herbicides were applied with a skidder-mounted hydraulic sprayer equipped with a cluster nozzle; Ally® with a.i. at 36 and 72 g/ha, Oust® with a.i. at 150 and 300 g/ha, all in water at 447 L/ha. ***Experimental Design*** — Completely randomized layout of 25 × 50 m treatment plots with five replications of the control plots and four replications of each of the treatments. ***Measurements Taken*** — August 1986; pre-treatment cover and health of raspberry and grass from one 2-m radius subsample within each replication, health of brush species from a 5-m radius subsample within each replication. June 1987; health, height, height increment, and root-collar diameter of 20 crop trees at the time of planting from within each replication. August 1987; repeat measurements of weeds and crop. **Results:**

	Percentage Cover						Health* of Crop Trees		
	Raspberry			Grass			At Planting		+ 1 Season
Treatment	pre		post	pre		post	June 1987		August 1987
Untreated	55.0^{a}		68.5^{a}	5.0^{a}	**	28.0^{a}	27^{a}	**	21^{a}
Ally® (36 g)	36.3^{a}	**	3.8^{b}	13.8^{a}		17.5^{a}	29^{a}	**	36^{ab}
Ally® (72 g)	21.3^{a}		5.0^{b}	13.8^{a}		22.5^{a}	32^{a}		31^{ab}
Oust® (150 g)	36.3^{a}	**	11.3^{b}	12.5^{a}	**	1.3^{a}	30^{a}		35^{ab}
Oust® (300 g)	47.5^{a}	**	5.0^{b}	10.0^{a}	**	0.0^{a}	31^{a}		41^{b}
F-Value	1.03		19.82	0.51		2.03	0.43		4.41
$P > F$	0.4237		0.0001	0.7271		0.1377	0.7833		0.0136

*Evaluated from 0 (healthy) to 100 (dead).

**Indicates differences between sample times (paired comparison with Student's t at 10%).

^{a,b}Indicate treatment differences - Tukey-Kramer with EW error at 5%.

Conclusions: Under the test conditions, both herbicides controlled raspberry at the rates tested. Oust® also controlled grass but did not affect brush species. Ally® only had marginal effect on brush species (sugar, red and mountain maple, hazel, white birch, and elderberry) and no effect on grass. Both herbicides caused damage to 2+2 black spruce planted the spring following treatment. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Weed efficacy and crop tolerance after site prep with sulfometuron-methyl and metsulfuron-methyl: spring soil vs. summer foliar treatment. 1986-P. **Objective:** To generate weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and the site prepared with a Letourneau crusher the summer of 1985. Herbicide treatments took place May 29–30, 1986, and August 15, 1986, and 2 + 2 bareroot black spruce were planted in June 1986 and 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Primarily silty clay loams and silty clays with a 1- to 10-cm duff layer. CEC and pH range from 8.4 to 33.5 and 3.8 to 6.2, respectively. ***Application Specifications*** — Both herbicides were applied with a skidder-mounted hydraulic sprayer equipped with a cluster nozzle; Ally® with a.i. at 36 and 72 g/ha, Oust® with a.i. at 150 and 300 g/ha. Spring treatments were applied in water at a total volume of 460 L/ha and summer treatments in water at 447 L/ha. ***Experimental Design*** — Completely randomized layout of 25 × 50 m treatment plots with five replications of the control plots and four replications of each of the treatments. ***Measurements Taken*** — August 1986 and 1987. Cover and health of raspberry and grass from one 2-m radius subsample within each replication. Health of brush species from a 5-m radius subsample within each replication. Health, height, height increment, and root-collar diameter of 20 crop trees at the time of planting and one growing season later from within each replication. **Results:**

	One Growing Season After Treatment						
	Percentage Cover						
	Raspberry		Grass		Health* of Crop Trees		
Treatment	May	Aug.	May	Aug.	May		Aug.
Untreated	55.0^{a}	68.5^{a}	5.0^{a**}	28.0^{a}	26^{a}		21^{a}
Ally® (36 g)	5.0^{b}	3.8^{b}	1.3^{a}	17.5^{a}	40^{b}		36^{ab}
Ally® (72 g)	3.8^{b}	5.0^{b}	5.0^{a}	22.5^{a}	47^{b}	**	31^{ab}
Oust® (150 g)	11.3^{b}	11.3^{b}	3.8^{a}	1.3^{a}	43^{b}	**	35^{ab}
Oust® (350 g)	7.5^{b}	5.0^{b}	1.3^{a}	0.0^{a}	51b		41^{b}
F-Value	6.27	19.82	0.94	2.03	12.93		4.41
P > *F*	0.0031	0.0001	0.4645	0.1377	0.0002		0.0136

*Evaluated from 0 (healthy) to 100 (dead).

**Indicates differences between application times (Student's *t* at 10%).

^{a,b}Indicates treatment differences – Tukey-Kramer with EW error at 5%.

Conclusions: Under the test conditions, Oust® performed equally well on raspberry and grass as a spring soil treatment or a summer foliar treatment. Oust® had very little effect on brush species at either application time. Ally® controlled raspberry equally well at both application times but did not control grass as a foliar application. Black spruce (2 + 2) planted the spring following summer foliar treatment appeared to be affected less by either herbicide than did the same stock planted immediately following spring soil treatment. It is recommended that planting be delayed one full growing season after treatment, no matter when treatment takes place. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Roden, M.J. Weed efficacy and crop tolerance after site preparation with liquid and granular hexazinone: spring vs. fall soil treatment. 1986-P. **Objective:** To collect weed efficacy and crop tolerance data for silvicultural purposes. **Location:** St. Leonard, New Brunswick. **Methods:** ***Site History*** — Previous stand of 45% balsam fir, 35% black spruce, and 20% tolerant hardwood was clearcut in the fall of 1984 and the site prepared with a Letourneau crusher the summer of 1985. Herbicide treatments took place May 27–29, 1986 and September 18–19, 1986, and 2+2 bareroot black spruce were planted in June 1986 and 1987. Raspberry and grass were the major competitors at the time of treatment. ***Soils*** — Fine textured, including loams, silty loams, clay loams, silty clays and clays. Duff varies from 3 to 11 cm. CEC and pH range from 6.2 to 18.9 and 3.6 to 4.9, respectively. ***Application Specifications*** — Granular hexazinone (Pronone® 10G) was applied with a skidder-mounted OMNI blower unit with a.i. at 2 kg/ha. Liquid hexazinone (Velpar® L) was applied with a skidder-mounted hydraulic sprayer equipped with a cluster nozzle, a.i. at 2 kg/ha, in a total volume of 364 L/ha (spring) and 436 L/ha (fall). ***Experimental Design*** — Completely randomized layout of 25 × 50 m treatment plots with five replications of each spring treatment and five, four, and three replications of the fall control, liquid, and granular treatments, respectively. ***Measurements Taken*** — August 1986 and 1987. Cover and health of raspberry and grass from one 2-m radius subsample within each replication. Health, height, height increment, and root-collar diameter of 20 crop trees at the time of planting and one growing season later from within each replication. **Results:**

	One Growing Season After Treatment						
	Percentage Cover						
	Raspberry		Grass			Health* of Crop Trees	
Treatment	May	Sept.	May		Sept.	May	Sept.
Untreated	55.0^{a}	68.5^{a}	5.0^{a}	**	28.0^{a}	26^{a}	21^{a}
Velpar® L	3.0^{b}	6.3^{b}	1.0^{a}	**	3.8^{a}	35^{a}	24^{a}
Pronone® 10G	6.5^{b}	12.5^{b}	3.0^{a}		5.8^{a}	37^{a}	25^{a}
F-Value	9.34	15.43	1.37		3.46	1.18	1.23
$P > F$	0.0036	0.0012	0.2908		0.0767	0.3461	0.3417

*Evaluated from 0 (healthy) to 100 (dead).

**Indicates differences between application times (Student's *t* at 10%).

^{a,b}Indicates treatment differences - Tukey-Kramer with EW error at 5%.

Conclusions: Under the test conditions there were no detectable differences in the efficacies of the spring and fall treatments of either hexazinone formulation. Both formulations effectively controlled raspberry and grass at both application times. There were no detectable differences in black spruce (2+2) tolerance to the spring and fall hexazinone treatments for either formulation. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Whitehead, R.; King, K. Three-year crop-tolerance and growth-response results of a glyphosate conifer release trial. 1984–87. **Objectives:** To generate crop tolerance data for silvicultural purposes and to demonstrate the crop growth response potential of glyphosate release. **Location:** Carnation Creek Watershed, Barkley Sound, Vancouver Island, B.C. **Methods:** ***Site History*** — Coastal cedar–hemlock forest in the watershed was logged from 1975 to 1981. Portions of the watershed received various silvicultural treatments between 1976 and 1983, including scarification, prescribed burning, and planting. Sitka spruce was the primary species planted. Glyphosate treatment took place September 6–15, 1984, to release planted and naturally regenerated conifers from red alder and salmonberry competition. ***Application Specifications*** — Glyphosate (Roundup®) was applied aerially with a Bell-47 helicopter, equipped with a Microfoil boom. An active rate of 2 kg/ha was applied in water at a total volume of 258 L/ha. Weather during applications varied, with easterly winds ranging from calm to gusty and temperatures between 14 and 21°C. Post-application rainfall varied but did not occur prior to 6 h after treatment. ***Experimental Design*** — Treated and untreated areas were systematically subsampled with a total of 36 and 5 permanent vegetation plots, respectively. Treated and untreated means were compared with a Student's t test. ***Measurements Taken*** — August/September 1985; one representative specimen of each crop species present at each subplot was numbered, tagged, measured for total height, height increment, and root-collar diameter, and assessed for its health value. Repeat measurements were made in 1986 and 1987. **Results:**

	1985			1986			1987		
Species	Control		Treated	Control		Treated	Control		Treated
				Health Value (0 = healthy, 10 = dead)					
Sitka spruce	0.2	=	0.0	0.8	=	0.4	0.0	=	0.0
W. red cedar	0.0	>	0.8	0.0	=	0.4	0.0	=	0.0
W. hemlock	0.0	>	0.3	0.2	=	0.0	0.0	=	0.0
				Root-Collar Diameter (cm)					
Sitka spruce	2.9	<	3.9	3.7	<	5.0	4.5	<	6.3
				Root-Collar Diameter Increment (cm)					
Sitka spruce	0.6	=	0.8	0.8	<	1.1	0.8	<	1.3

< Indicates that the control specimens are significantly different from the treated (Student's t at 10%).

Conclusions: Some minor crop injury (shoot and leader kill) was observed on hemlock and cedar one growing season after treatment. No incidences of mortality or subsequent stem deformity were observed, and the injured trees fully recovered one growing season later. Sitka spruce was unharmed by the treatment. Sitka spruce root-collar diameter and increment increased significantly in response to the release treatment. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

REYNOLDS, P.E.; Pitt, D.G.; Whitehead, R.; King, K. Three-year weed efficacy results of a glyphosate conifer release trial. 1984–87. **Objective:** To generate weed efficacy data for silvicultural purposes. **Location**: Carnation Creek Watershed, Barkley Sound, Vancouver Island, B.C. **Methods:** ***Site History*** — Coastal cedar-hemlock forest in the watershed was logged from 1975 to 1981. Portions of the watershed received various silvicultural treatments between 1976 and 1983, including scarification, prescribed burning, and planting. Sitka spruce was the primary species planted. Glyphosate treatment took place September 6–15, 1984, to release planted and naturally regenerated conifers from red alder and salmonberry competition. ***Application Specifications*** — Glyphosate (Roundup®) was applied aerially with a Bell-47 helicopter, equipped with a Microfoil boom. An active rate of 2 kg/ha was applied in water at a total volume of 258 L/ha. Weather during applications varied, with easterly winds ranging from calm to gusty and temperatures between 14 and 21°C. Post-application rainfall varied but did not occur before 6 h after treatment. ***Experimental Design*** — Treated and untreated areas were systematically subsampled with a total of 36 and 5 permanent vegetation plots, respectively. Treated and untreated means were compared with a Student's *t* test. ***Measurements Taken*** — August/September 1985, 1986, and 1987. All weed species were evaluated on a scale of 0 to 10 for their health (0 = healthy, 10 = dead). Herbaceous and brush species were assessed within a 1.8- and 25-m radius of subplot center, respectively. **Results:**

	1985			1986			1987		
Species	Control		Treated	Control		Treated	Control		Treated
Red alder	0.0	<	6.2[a]	1.0	<	3.8	0.0	<	3.2
Salmonberry	0.0	<	8.4	1.2	<	4.4	0.0	<	5.0
Thimbleberry	0.0	<	4.8	0.6	=	1.5	0.5	<	0.0
Salal	0.0	=	0.0	0.0	<	1.0	0.0	=	0.1
Sword fern	0.0	<	4.0	0.0	=	0.0	0.0	=	0.0
Deer fern	0.0	<	8.7	0.0	<	6.0	0.0	<	1.5
Lady fern	0.0	<	7.9	3.2	=	1.1	0.0	=	0.5
Red huckleberry	0.0	<	2.1	2.6	=	2.1	0.0	=	0.1
Elderberry	0.0	<	7.2	1.8	=	1.4	0.8	=	1.3

< Indicates that the control specimens are significantly healthier than the treated.

[a] Evaluated from 0 (healthy) to 10 (dead).

Conclusions: A health value of 6 or higher is considered to represent effective control of a given species. In this light, glyphosate treatment effectively controlled the major competitors for 1 year, with control declining after 2 and 3 years. Although control of salmonberry was excellent, control of alder was variable. Salal, as expected, was not harmed by the glyphosate. **(Forestry Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario)**

ROY, D.N.; Konar, S.K.; Charles, D.A.; Feng, J.C.; Prasad, R.; Campbell, R.A. Determination of persistence, movement, and degradation of hexazinone in selected Canadian boreal forest soils. 1985–88. **Objective:** To study the persistence, mobility, and degradation of hexazinone in boreal forest soils. **Location:** Lamplugh and Harker townships, 40 km east of Matheson, Ontario. **Methods:** One flat site for persistence and leaching studies and one sloping (7–8°) site for a mobility study for each type of soil (clay and sand) were selected. Each site (20 × 20 m) was divided into five replicate chemical application strips separated by buffer zones (1 × 20 m). Each strip (2 × 20 m) was further subdivided into 10 squares (2 × 2 m) as sampling plots. Velpar® L (240 g/L hexazinone) was applied with a Pestex backpack sprayer on June 20, 1984, to replicate strips in each of the flat sites and to the zone of chemical application for the slope site. Deposit plates (20 × 20 cm) were used to collect and to evaluate hexazinone deposition on each plot. ***Soils*** — Soil samples were collected from sampling plots using a random number table. For the mobility sites, samples were also collected at 3, 6, 9, and 12 m downslope from the chemical application zone. Cores were taken with a soil auger (10-cm diameter). Soils at three depths up to 30 cm were collected and analyzed for residues of hexazinone and metabolites A and B by using gas chromatography. **Results:** ***Persistence*** — In both clay and sand sites, the time required for hexazinone residues to remain consistently below 50% of the highest residue values observed was 43 days. After 365 days post-spray, these residue values were reduced to 13.5% for the clay site and 8.5% for the sand site based on the highest residue values observed. The gradual decrease in hexazinone residue values was observed during 365 days post-spray for both the sites. Results of this study indicated that hexazinone is relatively nonpersistent in both clay and sand soils of boreal forests under climatically normal summer condition. ***Leaching*** — From the analysis of individual soil core layer (organic, organic to 15 cm, and 15–30 cm) it was evident that hexazinone had a very limited potential to leach vertically through the soil column under the conditions of this study. In fact, results showed that considering all the sampling times together, an average of 88% or more of the hexazinone was found in the upper organic layer at both clay and sand sites, yielding 98% or more recovery within 15 cm from the top of the soil surface. Therefore, hexazinone resides mainly in the organic layer and leaching is retarded in the mineral layers. ***Mobility*** — Based on results of this study at both clay and sand slope sites, there was no evidence of lateral movement of the hexazinone down the 7–8° slopes either in runoff water or through subsurface flow. Hexazinone in the quantifiable range (0.05 ppm) could not be detected either at a distance 3 m from the top of the application zone or in the runoff water collected in the trench. Metabolites A and B: The overall formation of these metabolites was low. The maximum amounts of metabolites A and B were 240 and 310 mg and 200 and 220 mg for clay and sand soil, respectively. Within the observation period, as hexazinone concentration decreased, concentrations of both metabolites A and B increased and then decreased, indicating that these are relatively nonpersistent metabolites. **Conclusion:** Results of this study indicated that hexazinone had very limited potential to leach vertically through the soil column. The mobility study showed that there was no evidence of lateral movement of the herbicide either in runoff water or through subsurface flow. **(Forestry Canada, Forest pest Management Institute, Sault Ste. Marie, Ontario)** Publ. No. A-30, C-49

Chapter 7. Northwest Region Summaries

BALL, W.J. CFS-Abitibi-Price site-stock trials. 1987-P. **Objective:** To continue testing the field performance of two types of spring-planted black and white spruce on trenched and untrenched open areas and corridors previously winter-bladed and sprayed with Vision®. **Location:** Pine Falls, MB Eastern Region, elevation 256 m. **Methods:** ***Site History*** — Stand composition: Trembling aspen 70%, white spruce 30%; age 80–100 years; height 26 m. Harvest method: White spruce winter cut and skid 1962–63; mechanical site preparation: (a) Primary: Corridors (two blades wide) winter 1988 and open area bladed with D7G tractor equipped with a Rome side cutting blade. (b) Secondary: Corridors and open area trenched alternately with a Donaren disc trencher. Competition: 30-year aspen, balsam poplar, alder, and willow. ***Soils*** — Clay to sand. Duff 5–10 cm. Moisture regimes 4–6. ***Application Specifications*** — Chemical treatments: Ground application August 1988 applied with Clark 664 skidder equipped with two 450-L tanks. Swath width 5.5 m in strips and 11 m in open areas. Boom none; one cluster nozzle. Application rates: 3.0 L/ha. Carrier-water. No adjuvants. Total volume 112 L/ha. ***Experimental Design*** — Strip areas; two split block experiments with two main treatments (trenched and untrenched) × 10 blocks × 20 samples × 2 stock types × 2 species for 1600 pinned seedlings. Open areas; two split block experiments with two main treatments (trenched and untrenched) × 10 blocks × 20 samples × 2 stock types × 2 species for 1600 pinned seedlings. Transplant stock was fresh-lifted and planted in May; current crop of Can-Am 2 containers was planted in June. ***Measurements Taken*** — Height and root collar diameter were measured in June and October 1989. **(Forestry Canada, Manitoba District Office, Winnipeg, Manitoba)**

BALL, W.J.; Jarvis, J. The effect of scalping and cultivating (prior to planting) on the survival and growth of white spruce on mesic clay loams. 1962–86. **Objectives:** To determine effects of blading, no blading, spading, and controls on survival and growth of white spruce transplants. **Location:** Riding Mountain National Park, elevation 690 m. **Methods:** ***Site History*** — Mixedwood stands of overmature trembling aspen and uneven-aged white spruce with a dominant understory of beaked hazel. Half of each block was severely scalped with a bulldozer; half of each of these main treatments was spaded. Ten blocks were prepared in 1962, 1963, and 1964 for planting of uniformly graded white spruce transplants in 1963, 1964, and 1965. Areas were fenced, shrubs such as hazel were cut with a "brush master" and all vegetation was mowed with a lawnmower until 1969; fences were removed shortly after 1969. ***Soils*** — Moderately well-drained Orthic Gray Luvisols. Blading depth 15 cm; spading 30 cm. ***Experimental Design*** — Split plot; each 12.2 × 12.2 m plot divided in half; randomized main plots were (1) summer-bladed in 4.9-m-wide strips and (2) not bladed. Half of each main plot was subdivided at random into spaded (soil turned over manually with a shovel) subplots. ***Measurements Taken*** — Height growth and mortality data were measured annually until 1969 and thereafter in 1973, 1981, and 1986. **Results:** All three years of replication show clearly that summer blading improved long-term survival of white spruce transplants significantly. However, this treatment had a profound, lasting, and significant impact on total height, height increment, and diameter. The spading treatment, which did not affect growth, improved survival on nonbladed plots in two of the three trials. Diameters on nonbladed plots averaged 60% greater than those on bladed plots. Total height 21–23 years after planting averaged more than 1 m, or about one-third more on nonbladed plots. Annual height increment was significantly greater on nonbladed plots in all replications, even at age 8–10, indicating that differences in total height are still increasing. **(Forestry Canada, Manitoba District Office, Winnipeg, Manitoba)**

BRACE, L.G. Silvicultural assessment of selected methods of site preparation and crop release in areas designated for softwood production in Alberta - main test site - Grande Prairie. 1986-P. **Objectives:** Assess effects of selected manual, mechanical, chemical, and combined treatments for site preparation and release of white spruce and lodgepole pine crop trees, and assess effects of chemical treatments on small-mammal populations. **Location:** 21 km south of P & G pulp mill, Grande Prairie, Alberta (Improvement district 16, NTS Big Mountain Creek sheet), mixedwood forest complex of Alberta. **Methods:** ***Site History*** — Clearcut in 1983, aspen 80% 70–80 years old and 18–24 m high with 20% lodgepole pine. ***Treatments*** — Hexazinone (Pronone® 10G), with a.i. at 2 and 4 kg/ha in August 1986; hexazinone (Pronone® 10G) in August 1986 + disc trenching in May 1987; mechanical only (disc trenching, Rome disc) in May 1987. ***Planting*** — All treatment plots planted with Plug + 1 white spruce and container-grown lodgepole pine in May/June 1987. Competition at the treatment site consisted primarily of dense aspen regrowth and reed grass. ***Soils*** — Solonetzic Gray Luvisols developed on lacustro-till, 25–60% OM in 4–15 cm thick LH layer, moderately to imperfectly drained. ***Application Specifications*** — Granular hexazinone applied by isolair bucket attached to a helicopter flown at 33.5-m height and at 72.4 km/h. ***Experimental Design*** — Randomized complete block layout with three replicates of each block, treatment plots were 80 × 150 m with 30 × 100 m sampled for vegetation (30 plots, 5 × 5 m, for stem density and 120 plots, 1 × 1 m, for cover estimates in each treatment plot). ***Measurements Taken*** — Spring 1986 to fall 1988; competing vegetation measurements according to ECW protocols (vigor, height, status, damage) and crop tree survival and growth (height, diameter). **Results:** Crop-tree, competing vegetation, and small-mammal results tentative and no published report to date. **Conclusions:** 3 year results 1990/91 and 5-year results 1992/93. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

CORNS, I.G.W. Synthetic mulches to control *Calamagrostis canadensis*. 1987-P. **Objective:** To evaluate the effectiveness of synthetic mulches to control grass competition around planted white spruce seedlings. **Location:** Boreal mixedwood (B18a; Rowe 1972) of north-central Alberta, 20 km southeast of Slave Lake, Alberta. **Methods:** ***Site History*** — A potential white spruce site had a dense cover of marsh reed grass on a logged and burned area where it was not feasible or practicable to use mechanical site preparation equipment. ***Treatments*** — Five treatments plus an untreated control are being evaluated, and consist of the following: 6-mm black polyethylene, Dupont Typar (commonly used on the underside of boxspring mattresses), tarpaper, and Nilex-C24 (a locally made black felt-like polypropylene geo-textile used in stabilizing earth fills) and 30 × 30 cm hand scalps to mineral soil. The materials were cut in 90 × 90 cm squares with a slit in the center to accommodate a 3+0 bare root spruce seedling planted directly into the grass sod. The mulch was placed over the planted seedling and either pinned or weighted on the corners to keep the mat in place. ***Soils*** — Soils were dominantly imperfectly drained Gleyed Gray Luvisols devloped on clay loam till parent material. A dense 10-cm thick grassy sod was present. Temperatures under the mats were measured throughout the growing season with a CR 21X micrologger. ***Experimental Design*** — Randomized block design with 30 replicates. **Results:** Although the statistical analyses remain to be completed, after three growing seasons all treatments are obviously superior to the controls that suffered heavy mortality. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C. Cross-wind effect on aerial application of granular hexazinone. 1986–87. **Objective:** To determine the cross-wind effect on the aerial application of granular hexazinone, Pronone® 10G. **Location:** Grande Prairie, Alberta. **Methods:** A blank formulation of Pronone® 10G was used. The granules of the blank formulation were without hexazinone (a.i.) but were surface-coated with the protective layer similar to that of the commercial formulation. The weight of granules of the blank formulation was 10% less than the commercial formulation, that is, less 10% a.i. Granules were aerially applied at a nominal 20 kg/ha rate by using a Bell-206 helicopter equipped with an Isolair 2600-45 bucket applicator-spreader under either calm or 8 km/h cross wind conditions. The helicopter flew at 72.4 km/h in one direction at a 33.5-m elevation over a 100-m flight path on levelled ground (6 ha). Two 40-m long sampling transects, perpendicular to and centered on the flight path, were placed at 25 and 75 m. Ten 4-m sections on each transect were marked from the center to both the left-hand and the right-hand sides. Four 0.11-m^2 collection trays were placed in each 4-m section at 1-m spacing. Total weight of granules per 4-m transect was divided by the collection area (0.44 m^2) and then converted to kg/ha deposition rate. Granule distributions under no-wind and 8 km/h cross-wind conditions were compared by using the averaged rates of four transects from duplicated applications. **Results:** Deposition data showed that there was no change in the pattern of granule deposition under 8 km/h cross-wind, except a slight shift at the tail ends of a transect, that is, at the 17–20 m section, deposition rate reduced from 2.3 to 0.4 kg/ha at the left-hand side and increased from 1.1 to 3.3 kg/ha at the right-hand side of the swath, when 8 km/h wind blew from the left to right.

		Deposition of granular hexazinone (kg/ha)			
		Left-hand side		Right-hand side	
Distance[a] (m)	No.	Wind[b]	Calm	Wind[b]	Calm
1– 4	4	22.4 ± 1.5	24.4 ± 5.0	20.3 ± 3.0	21.2 ± 2.2
5– 8	4	27.7 ± 5.4	24.1 ± 7.9	16.1 ± 3.8	15.5 ± 4.8
9–12	4	9.8 ± 5.8	19.4 ± 4.2	15.4 ± 3.2	14.4 ± 4.7
13–16	4	5.8 ± 2.3	6.8 ± 3.9	10.0 ± 2.6	11.0 ± 3.8
17–20	4	0.4 ± 0.5	2.3 ± 3.4	3.3 ± 2.3	1.1 ± 1.8

[a] Distance (m) from the center of the application swath (flight path).

[b] Cross-wind (8 km/h) blew from the left to right of a collection transect and perpendicular to the flight path.

(Forestry Canada, Northwest Region, Edmonton, Alberta)

FENG, J.C. Granular herbicide application by helicopter equipped with an aerial bucket spreader. 1986–87. **Objective:** To evaluate the performance of an aerial bucket spreader in operational application of granular hexazinone. **Location:** Grande Prairie, Alberta. **Methods:** The site was a 3-year-old clearcut forest dominated by aspen at a 1-m average height. Granular formulation of hexazinone (Pronone® 10G) was aerially applied in three parallel "effective swaths" (defined as two swaths overlapping at tail ends of 50% nominal rate of application to produce a smooth distribution of herbicide) by using an Isolair Series 2600-45 bucket spreader attached to a Bell-206 helicopter flown at 72 km/h at a 34-m elevation under windless conditions. The width of effective swath was determined to be 27 m wide through previous calibration runs. Three parallel effective swaths would cover the width of each treatment plot (80 × 200 m, width/length). Granular hexazinone was applied at two rates, 20 and 40 kg/ha, and each rate was repeated three times. Granule deposition within the central 40-m width was collected at two transects laid at both ends of each plot. Eighty-one polyethylene collection trays (40.5 × 27 × 10 cm, length/width/depth), comprising a total surface of 9 m^2, were placed along each transect and were centered lengthwise at each 0.5-m spacing. The distance between trays on the transect was <0.1 m. A tray of granules was weighed separately and was converted into kilogram per hectare rates. **Results:** Mean rate of deposition (± SD) varied for every 5-m spacing per plot (n = 20 trays) was probably due to swath overlapping at both ends and was summarized as follows:

Collection distance (m)	Mean rate of granule hexazinone deposition (kg/ha ± SD)			
	Plot 1	Plot 2	Plot 3	Mean ± SD
Treatment 1: High rate (40 kg/ha)				
0– 5	34.9 ± 12.9	47.8 ± 16.3	44.4 ± 13.6	42.4 ± 6.7
5–10	46.1 ± 11.7	57.8 ± 12.4	55.9 ± 12.0	53.3 ± 6.3
10–15	35.6 ± 12.0	42.4 ± 14.3	45.3 ± 14.7	41.1 ± 5.0
15–20	29.7 ± 11.0	33.9 ± 12.2	29.8 ± 13.7	31.1 ± 2.4
20–25	29.4 ± 14.9	37.4 ± 13.0	28.3 ± 8.5	31.7 ± 5.0
25–30	37.0 ± 13.6	42.6 ± 14.4	33.4 ± 10.4	37.7 ± 4.6
30–35	34.4 ± 19.5	57.3 ± 14.3	51.7 ± 16.9	47.8 ± 11.9
35–40	28.3 ± 11.3	50.8 ± 18.0	44.0 ± 14.8	41.0 ± 11.5
				40.8 ± 7.5
Treatment 2: Low rate (20 kg/ha)				
0– 5	23.0 ± 19.8	27.4 ± 10.6	19.0 ± 7.1	23.1 ± 4.2
5–10	27.2 ± 17.2	29.1 ± 11.5	16.8 ± 7.1	24.4 ± 6.6
10–15	24.2 ± 10.3	19.7 ± 11.8	15.5 ± 7.9	19.8 ± 4.4
15–20	18.7 ± 9.5	15.6 ± 5.4	14.7 ± 6.9	16.3 ± 2.1
20–25	20.9 ± 9.2	17.3 ± 7.4	17.6 ± 9.3	18.6 ± 2.0
25–30	21.7 ± 11.5	19.7 ± 7.0	25.8 ± 11.3	22.4 ± 3.1
30–35	34.7 ± 19.9	24.1 ± 11.3	38.1 ± 14.8	32.3 ± 7.3
35–40	34.8 ± 18.4	18.4 ± 8.6	36.9 ± 11.8	30.0 ± 10.1
				23.4 ± 5.5

(Forestry Canada, Northwest Region, Edmonton, Alberta)

FENG, J.C. Persistence, mobility and degradation of hexazinone in forest silt loam soils. 1984–86. **Objectives:** To study the persistence, degradation, vertical leaching, and lateral movement of hexazinone in forest silt loam soils. **Location:** Stewart Lake, Peace River area, British Columbia. **Methods:** ***Site History*** — The original 10-year-old aspen stand of fire origin on this 5.6-ha experimental site was cut, windrowed, and partially burned in 1981, and planted with 2-0 bareroot white spruce in June 1982. The site was typical of areas requiring conifer release in northern Alberta and the Peace River area of British Columbia. ***Soils*** — The silt soil (sand 23%, silt 58%, clay 19%) contained 1.5% organic matter. The surface duff and humus was 5-10 cm thick. ***Treatments*** — Hexazinone (Velpar® L 240 g/L a.i) was applied May 5, 1984, at a rate of 4.3 kg/ha a.i. by a Bell-47 helicopter with a Microfoil boom. First rain event occurred on the next day and lasted for 4 days. The first day precipitation was 1.27 mm and the total for 4 days was 3.64 mm. Three 12 × 12 m experimental plots each were established within the treated area for persistence and leaching studies, and at 20 m and 40 m downslope of the treated area on a 5–10% gradient for lateral movement studies. ***Measurements Taken*** — Fifty cores of soil samples were taken randomly and pooled from each of three plots with a 2.5-cm diameter soil auger. Soils were collected separately at three layers, including the organic layer and depths 0–15 and 15–30 cm in the underlying mineral soils. Sampling intervals included pre-spray and 9, 23, 55, and 104 days after treatment. Residues of hexazinone and its metabolites A and B were extracted, cleaned-up, and quantitated by gas chromatography. **Results:** Sixty-six percent (66%) of hexazinone was degraded and dissipated at the end of 104-day period, decreasing from 7.12 mg/g (9 days) to 2.09 mg/g (104 days). The higher amount of metabolite-A (30–50% of hexazinone detected) compared with metabolite-B (0-12%) indicated higher hydroxylation than demethylation activity in the silt loam soil. Leaching of hexazinone and its metabolites from the surface organic to the underlying 0-15 cm mineral soil layer was found only in the 55-day sample. No residues of hexazinone and its metabolites were detected at deeper (15-30 cm) soil horizons. The lateral movement was not detected at distances of 20 m and 40 m outside of the treated block on a 5–10% slope.

Days			Mean Concentration, ppm (mg/g) ± SD		
post-spray	Soil layer	No.	Hexazinone	Metabolite-A	Metabolite-B
9	Surface organic	6	7.12 ± 0.17	2.12 ± 0.03	0.24 ± 0.03
	Mineral 0-15cm	2	<0.03	<0.06	<0.06
	15-30cm	2	<0.03	<0.06	<0.06
23	Surface organic	3(2)	2.87 ± 0.10	(1.28)	(0.14)
	Mineral 0-15cm	2	<0.03	<0.06	<0.06
	15-30cm	2	<0.03	<0.06	<0.06
55	Surface organic	2	1.43	0.53	<0.14
	Mineral 0-15cm	2	0.20	0.10	<0.06
	15-30cm	2	<0.03	<0.06	<0.06
104	Surface organic	7	2.09 ± 0.07	0.86 ± 0.12	0.25 ± 0.03
	Mineral 0-15cm	2	<0.03	<0.06	<0.06
	15-30cm	2	<0.03	<0.06	<0.06

(Forestry Canada, Northwest Region, Edmonton, Alberta)

FENG, J.C.; Campbell, R.A. New methods for soil sampling and residue reporting in a study on persistence of Velpar® L in boreal forest soils. 1983–85. **Objectives:** To develop soil sampling, residue analysis, and reporting methods to provide direct comparison of soil residue levels and rate of application of forestry herbicides. **Location:** Lamplugh Township, Ontario. **Methods:** Two plots of 2 ha each were treated with Velpar® L (a.i. 4 kg/ha) aerially on May 21, 1983. Each individual swath was flagged for accuracy. ***Soils*** — Soil type was clay covered by various thicknesses of organic matter, duff, and decomposed wood. ***Experimental Design*** — Sampling plots were cleared according to the requirement established by the Environmental Protection Service, by removing slash and large debris but without disturbing the forest floor. ***Measurements Taken*** — Soil cores (10 cm in diameter, and 0–15 cm and 15–30 cm in depth), were taken from seven sampling points in two treated plots with a sampler that opens from the side and allows observation of soil profiles and precise slicing of the core. The new analytical procedure provided a correction factor for each individual sample on the basis of weight (a variable) to volume (a constant) and then to area (a constant). The variation in forest floor sampling can therefore be determined without being biased by the variation of subsampling for residue analysis. **Results:** Average bulk density for the top soil layer (0–15 cm) was 0.81 ± 0.30 (n=77) with a range between 0.20 and 1.72, which demonstrated that an 8.6-fold error would be included in the conventional reporting for residues in individual samples. Hexazinone residue levels obtained by using both new and conventional methods are as follows:

Sampling date (1983–85)	Days post-application	Hexazinone residue level (0–15 cm layer)			
		Conventional method		New method	
		ppm (mg/g) ± SD	C.V. %	kg ai/ha ± SD	C.V. %
May 21	0	1.82 ± 0.93	51	2.12 ± 0.74	35
May 27	6	2.41 ± 2.45	102	2.29 ± 1.63	71
June 7	17	1.42 ± 1.12	79	1.47 ± 0.81	55
June 21	31	2.20 ± 1.57	71	1.74 ± 0.75	43
July 5	45	1.03 ± 0.47	46	1.26 ± 0.46	37
Aug. 3	74	0.90 ± 0.43	48	1.06 ± 0.47	44
Sept. 6	108	0.47 ± 0.35	74	0.53 ± 0.27	51
Oct. 22	154	0.72 ± 0.61	85	0.50 ± 0.46	92
May 16	360	0.48 ± 0.45	94	0.44 ± 0.37	84
Oct. 16	514	0.40 ± 0.49	123	0.34 ± 0.29	85
Oct. 8	871	0.17 ± 0.11		0.19 ± 0.10	53

Results: Results showed improvement in C.V. (%) as well as better fit to the degradation curve for hexazinone residues in the top soil layer (0–15 cm) with the new method. Soil samples from the lower layer (15–30 cm) contained nondetectable or trace amount of hexazinone throughout the 871-day monitoring period. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Ehrentraut, G.B.; Drew, T.J. Deposition of hexazinone from a logarithmic sprayer. 1987–88. **Objective:** To assess the performance of a logarithmic sprayer by determining hexazinone deposition in a trial for the silvicultural and economic effectiveness of hexazinone application. **Location:** Wandering River Ranger District, Lac La Biche Forest, Alberta. **Methods:** A backpack sprayer was fitted with a four-nozzle boom and a Model 725 Steady-Dilution-Logarithmic-Sprayer (R&D Sprayer Inc.) was used in these trials. Single swath application was repeated for each of four separate 2 × 50 m plots. The nominal application rates within each plot decreased from 9.0 to 0.56 kg/ha on a logarithmic scale over the 50-m length, as specified by the manufacturer:

Distance (m):	0	12.5	25.0	37.5	50.0
Nominal rates (kg/ha):	9	4.5	2.3	1.1	0.56

Hexazinone deposits were collected along ten transects laid out between 5 and 50 m at 5-m spacing. **Results:** The regression analysis of mean values of four plots indicated that hexazinone deposition was decreasing on a logarithmic scale along the length of the swath with a correlation coefficient (R) of 0.97. The coefficient of determination (R2) indicated that the semilog transformed linear regression, log (mean rate) = Ao + A1 (distance), accounted for 95% of the variation in hexazinone deposition. The actual rates of application of the logarithmic sprayer produced a slightly higher intersect (Ao = 0.98) than that specified by the manufacturer (expected value = 0.95) and a faster rate of reduction in hexazinone deposition, a -0.033 slope (A1) compared with the expected slope of -0.024. The average deposition rates of any three plots produced results similar in consistency and accuracy to the average of four plots:

Treatment	Equation	R	N
Plot 1	$\text{Log } Y = 1.10 - 0.046 X^*$	0.85	10
Plot 2	$\text{Log } Y = 1.14 - 0.037 X$	0.81	10
Plot 3	$\text{Log } Y = 1.13 - 0.051 X$	0.83	10
Plot 4	$\text{Log } Y = 0.80 - 0.026 X$	0.83	10
Plots 1, 2	$\text{Log } Y = 1.07 - 0.036 X$	0.93	10
Plots 1, 3	$\text{Log } Y = 1.09 - 0.045 X$	0.88	10
Plots 1, 4	$\text{Log } Y = 0.87 - 0.031 X$	0.89	10
Plots 2, 3	$\text{Log } Y = 1.10 - 0.038 X$	0.90	10
Plots 2, 4	$\text{Log } Y = 0.99 - 0.029 X$	0.96	10
Plots 3, 4	$\text{Log } Y = 0.88 - 0.032 X$	0.89	10
Plots 1, 2, 3	$\text{Log } Y = 1.06 - 0.036 X$	0.96	10
Plots 1, 2, 4	$\text{Log } Y = 0.98 - 0.031 X$	0.97	10
Plots 2, 3, 4	$\text{Log } Y = 0.99 - 0.032 X$	0.97	10
Plots 1, 2, 3, 4	$\text{Log } Y = 0.98 - 0.033 X$	0.97	10
Expected	$\text{Log } Y = 0.95 - 0.024 X$	1.00	10

*Y = deposition (kg/ha); X = distance (m). Expected rate was based on the specifications of the log-sprayer.

Conclusions: To use the logarithmic sprayer effectively in silvicultural trials, the deposition pattern of hexazinone should be analyzed, and the spray application should be replicated three or more times. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Feng, C.C. Persistence of hexazinone in Alberta soils. 1986–88. **Objective:** To determine the persistence of hexazinone in Alberta soils, when applied as surface-coated granular formulation. **Location:** Grande Prairie, Alberta. **Methods:** Laboratory coated Pronone® 10G granules (1000 mg hexazinone per granule) were hand-planted on the surface of silty clay soils in a 3-year-old clearcut forest on August 28, 1986. The vegetation regrowth established on the 3-year-old cutover was dominated by aspen of 1-m average height. Methodologies to spike, apply, and retrieve granules were developed to control the size/a.i. variation of granules and to facilitate the subsequent sampling for planted granules and treated soils. Nine samplings were performed within 320 days after application. At each sampling, the granules were recovered, and soil samples were collected to a 10-cm depth immediately underneath the granule in a 10-cm diameter. Hexazinone residues from both granules and soils were extracted, cleaned-up, and quantitated by gas chromatography. Hexazinone residues recovered from granules were divided by the soil surface area sampled and then converted into application rate equivalent, kilograms/hectare. Residues of soil samples were converted similarly to kilograms/hectare rate equivalent by using sampling surface area and soil bulk density obtained from each individual soil samples. **Results:** Hexazinone treatment was equivalent to 4 kg/ha. Residues recovered from granules decreased rapidly from 3.73 kg/ha 1 day post-application to 0.01 kg/ha, 18 days post-application. Soil residues increased steadily during this period but not as fast as the rate of decrease in granules. The combined total residues from soil and ganules at each sampling time represent the level of hexazinone on the forest floor, which decreased rapidly from 4.33 to 1.31 kg/ha within 61 days after treatment, to 0.69 kg/ha over-the-winter, 285 days after, and to 0.27 kg/ha during the second growing season, 320 days after.

Days post-application	Sampling date	Soil residues (kg/ha)	Granule residues (kg/ha)	Total residues (kg/ha)
1	29-08-86	0.60	3.73	4.33
3	31-08-86	0.37	2.69	3.06
8	05-09-86	1.71	0.07	1.78
13	10-09-86	1.23	0.03	1.26
18	15-09-86	1.71	0.01	1.72
34	01-10-86	1.80		1.80
61	28-10-86	1.31		1.31
285	09-06-87	0.69		0.69
320	14-07-87	0.27		0.27

Conclusions: Results suggest that hexazinone residues were released rapidly from Pronone® 10G granules to soils. The released residues were then subjected to immediate root uptake and environmental dissipation, that is, vertical leaching, lateral movement, and degradation. Time required for total residues to dissipate to 50% of the application rate (DT50) was about 2 weeks (r = 0.92). **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Feng, C.C. Persistence of hexazinone two years after application in silty clay soil. 1986-P. **Objective:** To determine the long-term persistence of hexazinone, applied as Pronone® 10G, in northern Alberta silty clay soil. **Location:** Grande Prairie, Alberta. **Methods:** Laboratory prepared Pronone® 10G granules were hand-planted on the surface of silty clay soils in a 3-year-old clearcut forest on August 28, 1986. The vegetation regrowth established on the 3-year-old cutover was dominated by aspen of 1-m average height at the time of herbicide application. Methodologies to spike, apply, and retrieve granules were developed to control the size/a.i. variation of granules and to facilitate the subsequent sampling for planted granules and treated soils. Nine soil samplings from 4 kg/ha a.i. treatment plot between 1 and 320 days after application were performed and reported in 1988. Total residues of hexazinone within a 10-cm depth were 4.3, 3.1, 1.8, 1.3, 1.7, 1.8, 1.3, 0.69, and 0.27 kg/ha after 1, 3, 8, 13, 18, 34, 61, 285, and 320 days. By October 4–6, 1988, 25 months (770 days) after application, soil samples were taken from three blocks each (a total of nine plots) of the 2 and 4 kg/ha treatments. **Results:** Residues of hexazinone were reduced to about 1% of the original amount applied at 0.02 to 0.03 kg/ha in 2 and 4 kg/ha treatment plots, respectively.

Application rate (kg/ha)	Block no.	Hexazinone residues		
		No.	Measured amount ± SD (kg/ha)	% Applied ± SD
4	1	3	0.06 ± 0.03	1.5 ± 0.8
	2	3	0.02 ± 0.02	0.5 ± 0.4
	3	3	0.01 ± 0.01	0.3 ± 0.1
	Total	9	0.03 ± 0.03	0.8 ± 0.7
2	1	3	0.02 ± 0.02	1.2 ± 1.2
	2	3	0.02 ± 0.00	1.0 ± 0.0
	3	3	0.01 ± 0.01	0.7 ± 0.3
	Total	9	0.02 ± 0.01	1.0 ± 0.5

Conclusions: Results suggest that hexazinone residues released to soils were subjected to immediate root uptake and environmental degradation initially, and were reduced rapidly to about 5% the original amount applied during the 1st year. Dissipation of hexazinone continued, however, at a slower rate and reduced to about 1% the original amount applied during the 2nd year after treatment. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Navratil, S. Sampling for zero-time hexazinone residues in forest soils for dissipation study. 1987–88. **Objectives:** To develop a new soil sampling method using glass jars to measure zero-time herbicide residues and to compare it with a conventional method using a soil corer under forest conditions in northern Alberta. **Location:** Calling Lake Ranger District, 200 km north of Edmonton, Alberta. **Methods:** A liquid formulation of hexazinone (Velpar® L) was applied with a backpack sprayer at 3 kg/ha nominal rate. ***Soils*** — Soil samples were taken immediately following application by using the glass jar method (Feng, J.; Feng, C. 1988b) and corer method (Feng, J.C.; Klassen, H.D. 1986). Soil cores extracted with a corer were sliced into two layers, the upper layer (0–15 cm) and the lower layer (15–30 cm), samples of the glass method representing only the upper layer (0–10 cm). The corer method was also used to take soil samples at 210 and 360 days post-application. ***Measurements Taken*** — Hexazinone residues were determined by extraction, cleanup, and gas chromatography. Residue concentrations were converted to application rate equivalent (kg/ha) by using soil bulk density and sampling surface area. **Results:** Use of the glass jar method resulted in five times more efficient recovery of hexazinone residues from soils (3.8 kg/ha) than the conventional corer method (0.8 kg/ha) at zero-time. Hexazinone residues sampled by the corer method, after residues were carried into deeper soil layers by adequate moisture, were 2.0 and 0.35 kg/ha, respectively, 210 and 360 days after spraying.

Sampling method	Days after spraying	Hexazinone residue level (kg/ha)		
		Upper layer	Lower layer	Total
Glass jar	0	3.8	-	3.8
Corer	0	0.8	0	0.8
Corer	210	1.5	0.5	2.0
Corer	360	0.25	0.1	0.35

Note: The intended application rate was 3 kg/ha; sampling depths for the corer method were 0–15 cm for upper layer, 15–30 cm for lower layer, and 0–30 cm for total.

Conclusions: The combined use of glass jars for zero-time and the soil corer for subsequent samplings produced the best result in estimating the dissipation rate of hexazinone in forest soils. Because of the late application in the fall and frozen ground in winter, the dissipation time for 50% of hexazinone (DT50) was 206 days and the rate of dissipation followed a fortuitous linear rather than a logarithmic function of time. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Sidhu, S.S. Size variation and distribution of Pronone® 10G granules from aerial andground application. 1986–87. **Objectives:** To evaluate the size variation of granules of a new herbicide formulation, Pronone® 10G (10% hexazinone), and to establish the granule distribution pattern from a ground and an aerial applicators. **Locations:** Tests were performed with a ground applicator in Nisku, Alberta, and an aerial applicator in Grande Prairie, Alberta. **Methods:** Blank formulation of Pronone® 10G was used in all tests. An ACE Rotary Pellet Applicator (ACE Vegetation Control, Calgary, Alberta) and the Isolair 2600-45 bucket spreader (Isolair Inc., 20490 E. Aschoff Rd;, Rhododendron, Oreg.) were used in ground and aerial application tests, respectively. **Results:** Granule size ranged from 2.5 to 93 mg (average 20 ± 11 mg, n = 315) with 90% between 5 and 35 mg in a 10-kg lot of Pronone® 10G. The granule size frequency among weight classes did not change at various delivery distances from the truck-mounted ground applicator (ACE Rotary Applicator). The study indicated that individual granule size variation had the least direct impact on the distribution of active ingredient in a field operation. The ground application system did not produce a uniform distribution of Pronone® 10G granules within a 5-m wide test swath and uneven ground further increased the varied distribution. Average depositions were 11.3 ± 4.5 kg/ha (40% C.V.) and 15.6 ± 8.4 kg/ha (54% C.V.) for the target rates 20 and 40 kg/ha, respectively. A more reliable delivery and more uniform distribution of granules may be achieved when both the swath width and the distance towards starting boundary are increased to greater than 10 m. Aerial application with the helicopter-mounted bucket spreader (Isolair 2600-45) produced a 27-m wide effective swath. Average deposition rates were 19.2 ± 4.9 kg/ha (26% C.V.) and 39.1 ± 9.4 kg/ha (24% C.V.) for the 20 and 40 kg/ha applications, respectively. The off-center positioning of the metering valve of the aerial bucket possibly resulted in a 23% difference in granule deposition on either side of the swath center line. Optimal number of collection trays (0.11 m^2) for monitoring granule deposition from the aerial application system was estimated statistically for both deposition rates and over a range of probabilities:

Expected rate		Estimated Optimal No. of Trays			
(± % rate)	P =	0.20	0.10	0.05	0.01
20 kg/ha ± 5%		117	190	280	480
± 10%		30	50	70	120
± 15%		14	23	32	56
± 20%		9	14	19	33
± 25%		6	10	13	22
40 kg/ha ± 5%		63	103	145	255
± 10%		17	27	38	66
± 15%		8	13	19	32
± 20%		5	8	12	19
± 25%		4	6	8	14

Results: Results indicate tht there is a 90% certainty of measuring an average rate of deposition between 36 and 44 kg/ha when 27 trays are used to assess the 40 kg/ha rate of application, and between 18 and 22 kg/ha when 50 trays are used to assess the 20 kg/ha application. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Sidhu, S.S.; Feng, C.C. Leachability and persistence of hexazinone in deep soils. 1988-P. **Objective:** To determine residue level of hexazinone leached and persisted from the surface of forest floor to a 2.2-m depth, 2 years after application. **Location:** Grande Prairie, Alberta. **Methods:** The study site was clearcut in 1983, treated with hexazinone in 1986, and planted with white spruce and lodgepole pine in 1987. Weed competition was mainly from grasses, shrubs, and aspen of average height of 1 m in 1986 and 2 m in 1988. ***Soils*** — The texture was silty loam. Three soil horizons, LH, Ah, and Ae, occurred within the top 10 - 20 cm. Pronone® 10G was applied to 80 × 200 m plots at 2 and 4 kg/ha a.i. rates by a helicopter equipped with an Isolair bucket spreader on August 28, 1986 under no-wind condition. Two years after application, one soil pit in each treatment plot was dug 2.5 m deep with a backhoe. From each soil pit, soil discs 10 cm thick were taken in triplicates (three vertical sampling lines with 1-m spacing) from the surface to 220 cm deep at 20-cm intervals. Hexazinone residues were extracted, cleaned-up, and quantified by gas chromatography. Residue concentrations by weight (ppmw) were converted to a soil area basis (kg/ha) by using soil bulk densities of each horizon.

Soil depth (cm)	Hexazinone residues (kg/ha)					
	Treatment plot 1 (4 kg/ha)			Treatment plot 2 (2 kg/ha)		
	Line 1	Line 2	Line 3	Line 1	Line 2	Line 3
0– 10	0.030	0.034	0.036	0.005	ND	ND
30– 40	ND	ND	ND	(trace)	0.059	ND
60– 70	ND	ND	ND	ND	ND	ND
90–100	ND	ND	ND	ND	ND	ND
120–130	ND	ND	ND	ND	ND	ND
150–160	ND	ND	ND	ND	ND	ND
180–190	ND	ND	ND	ND	ND	ND
210–220	ND	ND	ND	ND	ND	ND

ND = nondetectable, < 0.03 ppmw.

Results: In the 4 kg/ha treatment, hexazinone residues were detected in the top 10 cm soils and averaged to about 0.8% of the original amount applied. In the 2 kg/ha treatment, only one sample showed small amounts of residues in the 0- to 10-cm layer. However, two samples showed residues at 30- 40 cm deep. Leaching along root channels in soils might be the cause of the downward movement of hexazinone in this area. No residues were found between 60 and 220 cm deep in the 2 kg/ha treatment plot and between 30 and 220 cm in the 4 kg/ha plot. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Sidhu, S.S.; Feng, C.C. Performance of a commercial ground applicator in granular hexazinone application. 1989-P. **Objectives:** To evaluate the performance and to determine the distribution of Pronone® 10G granules from a commercial ground applicator, Granul-Air, in a conifer release research trial. **Location:** Grande Prairie, Alberta. **Methods:** The site was clearcut in 1983, and disc-trenched and planted with white spruce and lodgepole pine in 1987. Weed competition was mainly from grasses and aspen at 3 m average height. Two plots each 80 × 200 m were designated for Pronone® 10G treatment at 20 and 40 kg/ha. Five 30-m transects for granule collection were laid in the center and were evenly spaced along the length of each plot. Fifteen 0.11 m^2 (41 × 27 × 10 cm length/width/depth) collection trays were set at a 2-m spacing along each 30-m transect. Granules collected in each tray were weighed and divided by collecting area to give deposition rate (kg/ha). Mean rate of 15 trays per transect were averaged to give mean deposition of each plot. Pronone® 10G was applied by using a truck-mounted Granul-Air applicator under no-wind condition on May 30, 1989. Truck traveled along the length of plot and perpendicular to the collection transects. **Results:** Mean deposition rates of Pronone® 10G granules for each transect are as follows:

Transect	Low dosage treatment (kg/ha ± SD)		High dosage treatment (kg/ha ± SD)	
1	23.4	14.6	55.6	59.6
2	18.3	27.3	73.7	53.6
3	20.2	22.8	48.1	63.5
4	25.3	22.4	51.0	62.2
5	15.4	27.3	50.9	58.3
Mean	20.5 ± 4.0	22.9 ± 5.2	55.9 ± 10.3	59.5 ± 3.9

The overall mean deposition rates of the low and high dosage treatments were 21.7 and 57.7 kg/ha, respectively. The low dosage application was calibrated before field treatment, which showed within 10% of the target rate. However, the high dosage application was not calibrated but proportionally set on the computer dial according to the low dosage calibration, and was over 40% higher than the target rate of 40 kg/ha. It was also observed that the truck tended to throw more granules to its right-hand side. This problem might be associated with the hydraulic design and wear-and-tear of the Granul-Air applicator. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Sidhu, S.S.; Feng, C.C.; Servant V. Hexazinone residues and dissipation in soil leachates. 1986–88. **Objectives:** To determine residues and dissipation of the granular herbicide hexazinone (Pronone® 10G) in soil leachate. **Location:** Grande Prairie, Alberta. **Methods:** A 3-year-old clearcut forest was aerially treated on August 28, 1986, with Pronone® 10G (10% hexazinone) at a.i. 0, 2, and 4 kg/ha. Triplicated soil leachate samples were collected over a 448-day period at 30, 55, and 80 cm deep for each treatment by using horizontally inserted collection tubes made of perforated PVC pipes. All leachate samples were individually analyzed for hexazinone (a.i.) residues by gas chromatography. **Results:** There was no or an insignificant volume of soil leachate in the collection bottles up to 112 daysafter application and before ground freeze. Leaching of hexazinone was triggered by the snow melt in spring 1987 and continued until the end of November 1987. Detected amounts of residues were the highest in the first post-winter collection 227 days after treatment, reaching 205 and 61 mg at 30 cm deep in the 4 and 2 kg/ha a.i. treatment plots, respectively, and reaching 89 and 39 mg at 80 cm deep; at 55 cm deep, the peaks were 178 mg after 264 days and 28 mg after 351 days in the 4 and 2 kg/ha a.i. treatment plots. Hexazinone residues declined to less than 17 mg after 448 days in all depths and in both herbicide treated plots. There were no hexazinone residues detected in the 0-treatment plot. The concentration of hexazinone in soil leachates was inversely related to the volume of leachate. The sample collected from the 4 kg/ha a.i. plot at 30 cm deep had the highest concentration (492 ppb) but the lowest volume (152 mL) 277 days after application, compared with samples collected at the same depth but at different times. In all cases the total amount of hexazinone residues in soil leachates increased with the rate of soil water percolation but declined over time.

Pronone® 10G (kg/ha)	Soil Depth (cm)	Equation[a]	R	N
20	30	$W = 163 + 0.0466V - 65.8 \log D$	0.94	7
	55	$W = 55.3 + 0.0252V - 22.0 \log D$	0.99	6
	80	$W = 111 + 0.0260V - 42.8 \log D$	0.86	7
40	30	$W = 1392 + 0.0378V - 536 \log D$	0.89	7
	55	$W = 1070 + 0.0505V - 414 \log D$	0.70	9
	80	$W = 411 + 0.0566V - 163 \log D$	0.88	6

[a] $W = A0 + A1\,V + A2 \log D$. W is the weight (mg) of hexazinone residues in soil water as estimated from the equation, D is number of days since treatment, and V is the volume (mL) of leachates collected at the time D. W and V were the totals of three samples for each depth and each time of collection.

(Forestry Canada, Northwest Region, Edmonton, Alberta)

FENG, J.C.; Stornes, V.; Rogers, R. The rate of release of surface-coated hexazinone from Pronone® 10G granules under laboratory and field conditions. 1986–88. **Objectives:** To establish the release rate of hexazinone from a new granular formulation, Pronone® 10G under both laboratory and forest conditions. **Locations:** Laboratory study was carried out in the Pro-Serve laboratory, Memphis, Tenn., and the field study was conducted in Grande Prairie, Alberta. **Methods:** ***Background*** — A new granular formulation of hexazinone, Pronone® 10G, is pending registration for forestry application in Canada. The use of Pronone® 10G may result in negligible off-site drift mainly because of its large particle size (2–5 cm), heavier weight (20 mg) and nonvolatile nature. The Pronone® 10G granules are surface-coated with 10% (w/w) hexazinone on a hard insoluble clay-base material. The granules are protected by an outer coating free of hexazinone. The hexazinone is released to the forest floor by the first available moisture, that is, rain and dew, etc., and percolates through soils as concentrated column. The higher concentration of herbicide in a column form may facilitate root uptake compared with the broadcast application of a liquid formulation at the same rate. However, a.i. leaching and persistence in deeper soils may increase. The behavior of the a.i. is further affected by its rate of release from the granule. ***Application Specifications*** — The amount of moisture required to dissolve the protective outer coating and to release the a.i. was studied under both laboratory and field conditions. A simulated rainfall apparatus was used in the laboratory study and a spiking/planting/retrieving system was used in the field study. Hexazinone residues were determined by gas chromatography. **Results:** The release of hexazinone from Pronone® 10G granules treated with 1.3, 2.5, and 5.1 cm of continual rainfall simulated in the laboratory were 65.5, 87.4, and 91.5% with C.V. of 8.7, 2.9, and 5.4%, respectively. Evidently, 90% release of hexazinone from Pronone® 10G granules can be expected with 2.5–5 cm of rainfall. In Alberta this amount of rainfall would normally occur within 15–30 days in May, June, August, and September, the recommended period for hexazinone use in forest vegetation management. A greater rate of release of hexazinone was observed under actual field conditions in a northern Alberta forest. The average releases of hexazinone were 26, 31, 36, 44, 91, 98, and 99% after 1, 2, 3, 4, 7, 8, and 13 days exposure to intermittent rain and overnight dew. The release of hexazinone was complete (100%) on the next sampling, 34 days after exposure with 104 mm cumulative rainfall. Results of multiple regression analysis suggest that the release of hexazinone depends on both rainfall and days of exposure to overnight dew.

Cumulative rainfall (mm)	No. of days required for release of hexazinone by percentages				
	50%	60%	70%	80%	90%
0.25	3	4	7	14	21
0.50	2	3	4	7	14
1.0	1	2	3	4	7
2.5		1	2	3	4
5.0			1	2	3
10.0				1	2
25.0					1

(Forestry Canada, Northwest Region, Edmonton, Alberta)

FENG, J.C.; Thompson, D.G. Persistence and degradation of glyphosate in foliage and soils of a canadian coastal forest watershed. 1984–87. **Objectives:** To investigate the environmental persistence and behavior of glyphosate and its major metabolite aminomethyl phosphonic acid (AMPA) in terrestrial components of a Canadian coastal forest watershed. **Location:** Carnation Creek watershed, Vancouver Island area, British Columbia. **Methods:** A helicopter equipped with Microfoil boom applied 2 kg/ha glyphosate to the 42-ha experimental site. Ground deposition of glyphosate were monitored with collectors (400 cm^2 each). A total of nine soil and six foliage sampling stations were monitored for 1 year. Residues of soil samples from three depth-layers were analyzed to determine the persistence and leaching of glyphosate and AMPA in both seasonally flooded and well-drained soils. Foliage and leaf litter of two brush species, salmonberry and red alder, were analyzed to determine initial foliage residues and residues associated with leaf litter to estimate the degree of residue input to the forest floor via leaf fall. **Results:** Both the deposit collector and soil residue methods provided average estimates of initial deposit rates (2.52 and 1.85 kg/ha, respectively), which were reasonably close to the nominal application rate of 2 kg/ha. Both data sets also indicated that deposition rates varied greatly between different sites, ranging from a low of 0.60 kg/ha to a high of 3.42 kg/ha. Time of application, meteorological conditions, and individual site characteristics may all have contributed to variable chemical deposits. Analyses of initial foliage samples also indicated highly variable chemical deposition. Residue levels in both salmonberry and leaf litter collected 15 days post-application were significantly lower ($P>0.05$) than initial foliage residues. Leaf litter residues of glyphosate and AMPA declined in both species over time and less than 1% remained 29 days post-application. The significant difference between initial foliage residues and the first leaf litter residues was attributed to wash-off resulting from a rainfall event that occurred 1 day post-application. Indications are that while leaf-litter residues would be an unimportant transient source of chemical contamination, wash-off of unabsorbed foliage residues may provide an important nonpoint source input, if rainfall occurs shortly after spraying. Soil residue determinations showed that both glyphosate and AMPA were retained primarily in the upper, organic-rich soil layer, 0-15 cm. Of 63 determinations of mean glyphosate distribution, only 10 data points indicated greater than 10% of total soil core residue in the 15–30-cm layer. No quantifiable residues were detected in samples taken from the 30–35-cm layer. Residues of glyphosate declined with time at all locations so that only 6–18% of initial levels remained after 360 days. Declining glyphosate residues coupled with transient increases in AMPA residues were indicative of microbial degradation. Insufficient replication, high variability in soil residues, and site location effects on chemical behavior prohibited accurate derivation of persistence endpoints by regression analysis. However, pooling of the data provided an approximate time to 50% dissipation of glyphosate from watershed soils of 45–60 days. The results of this 1-year monitoring study indicate that glyphosate and its major metabolite AMPA are susceptible to leaching under the conditions studied. The data provide no evidence of potential for long-term groundwater or surface water contamination as a result of inputs from terrestrial substrate. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

FENG, J.C.; Thompson, D.G.; Reynolds, P.E. Fate of glyphosate in a forest stream ecosystem. 1984–87. **Objectives:** To evaluate the performance of Microfoil boom and the effectiveness of a 10-m vegetation buffer in protecting aquatic ecosystems from aerial spray of glyphosate, and to determine the residue levels and dissipation rate of glyphosate in water, stream bottom sediments, and suspended sediment, of buffered and directly sprayed streams. **Location:** Carnation Creek watershed, Vancouver Island, British Columbia. **Methods:** Residues of glyphosate and its major metabolite aminomethyl phosphonic acid (AMPA) were monitored in stream water, bottom sediments, and suspended sediments for 1 year. Main channel and two tributaries were buffered with a 10-m wide vegetation strip, and two other tributaries were subjected to direct spraying of glyphosate at a nominal rate of 2 kg/ha. Initial deposits were monitored in the target spray area, within the buffer zone and main stream channel by using 400-cm^2 collection plates. Residues in the stream water and sediments were quantitated by using high-performance-liquid-chromatography. **Results:** Deposit values of glyphosate declined rapidly with distance off-target, with 1% of full application (1.88 kg/ha) found at 2 – 3 m. The lowest detectable residue in the alder area (1.55×10^{-3} kg/ha) was found at 17.2 m, and no residue was detected at 20.0 and 22.9 m. Quantifiable residue (1.8×10^{-4} kg/ha) was found up to 23.1 m in the salmonberry area. The off-target deposit extinction rate was found not significantly different ($P < 0.05$) between alder and salmonberry. No detectable residues of glyphosate nor AMPA were found in the buffered tributaries, indicating that the 10-m wide vegetation buffer strip effectively prevented stream contamination from drift and run-off when using Microfoil boom in an aerial application. The two tributaries directly treated with glyphosate behaved differently in residue dissipation depending on stream flow and degree of vegetation cover. Glyphosate concentrations in stream water 2 h after direct application showed a 100-fold difference between a rapid-flowing tributary (flow rate: 0.02 m^3/s; glyphosate concentration: 162 mg/L) and a slow-flowing tributary with dense vegetation cover (flow rate: 0.001 m^3/s; glyphosate concentration: 1.5 mg/L). Glyphosate concentrations decreased rapidly to 37 mg/L and to below detection limit, respectively, after 16 h. A second glyphosate peak was observed within 24 h on each tributary after the first rainfall (39 mm). Concentrations were 109 and 144 mg/L, respectively. Trace amounts (<1 mg/L) of glyphosate were detected in several samples following eight storm events during the first 150 days. No residues were detected in post-storm water samples between 150 days and 1 year. AMPA was detected at 1% of the glyphosate concentrations during the initial sampling period and did not accumulate. Low peak concentrations found in both directly treated tributaries coupled with rapid dissipation indicated a safety margin of 2 to 3 orders of magnitude for rainbow trout based on published LC_{50} values. No glyphosate residues were found in the stream bottom sediment in buffered tributaries between 23 days and one year. Directly treated tributaries showed higher glyphosate concentrations in bottom sediments than in water and persisted till the end of 1-year monitoring period. Suspended sediments collected from the main channel downstream of spray block indicated glyphosate input from the two directly treated tributaries through the first five storm events between 23 and 66 days. Results suggest a high risk of stream contamination may occur when rainfall is expected within 24–36 h and when the stream is not protected by a 10-m vegetation buffer. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

GARDNER, A. Stem injection and girdling of residual aspen. 1986–89. **Objectives:** Control of aspen sucker density following softwood removal. **Location:** Prince Albert, Saskatchewan; boreal mixedwood, elevation 451 m. **Methods:** ***Site History*** — 20°C (black spruce, jack pine, and trembling aspen clearcut in winter 1985–86) no site preparation or planting on experimental area, no revegetation at time of plot establishment. Residual aspen stems per hectare averaged 35 for herbicide treatment, 34 for girdling, and 27 for control; all stems healthy at time of treatment. ***Application Specifications*** — Three treatments investigated: herbicide, girdling, and control. Herbicide application by punch hammer and spot gun calibrated to deliver 1.0 mL of undiluted glyphosate formulation to punch holes located every 10 cm around stem circumference. Girdling by frilling with an axe. Weather was clear, 23°C, no wind. ***Experimental Design*** — Three replications per treatment were established. Plots are 100 × 100 m with 50 × 50 m sample plots located inside. A 25-m treated buffer surrounds each sample area. A total of 9 ha for the experiment is arranged in a completely randomized single-factor design. ***Measurements Taken*** — Aspen density, average total height of aspen, morphological and physiological description of aspen, and dominant vegetation. **(Forestry Canada, Northwest Region, Saskatchewan District Office, Prince Albert, Saskatchewan)**

MAYNARD, D.G. Nutrient cycling and dynamics in relation to toxic substances and silvicultural practices. 1986-P. **Objectives:** Determine the influence of herbicide application on nutrient cycling and the decomposition of organic matter. **Location:** 21 km south of P & G pulp mill, Grande Prairie, Alberta (Improvement district 16, NTS Big Mountain Creek sheet), mixedwood forest complex of Alberta. **Methods:** ***Site History*** — Clearcut in 1983, aspen 80% 70–80 years old and 18-24 m high with 20% lodgepole pine. ***Treatments*** — Pronone®, with a.i. at 2 and 4 kg/ha hand applied in 15 plots, 8 × 8 m. Competition at treatment time consisted primarily of dense aspen regrowth and reed grass. ***Soils*** — Solonetzic Gray Luvisols developed on lacustro-till, 25–60% OM in 4–15-cm thick LH layer, moderately to imperfectly drained. ***Application Specifications*** — Hexazinone (Pronone® 10G) applied by hand. ***Experimental Design*** — Randomized complete block layout with five blocks (8 × 8 m). ***Measurements Taken*** — Measurements taken in 1987 and 1988 on stem density of woody species over 50 cm and cover of all species, litter in litter collectors, soil leachates from lysimeters. **Results:** Available in 1990. **Conclusions:** In 1990–91. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

NAVRATIL, S.; Hayward, R. Control of aspen development in areas designated for softwood production I. 1986-P. **Objectives:** To assess effects of chemical single-tree pre-harvest treatments and mechanical, manual, and chemical treatments for site preparation and release on density and growth of aspen regeneration. **Location:** Main test site is 21 km south of P & G pulp mill, Grande Prairie, Alberta, mixedwood forest. **Methods:** ***Site History*** — Clearcut in 1983, 80% 70–80 years old and 18–24-m aspen with 20% lodgepole pine. ***Treatments*** — Hexazinone (Pronone® 10G), with a.i. at 2 and 4 kg/ha in August 1986; hexazinone (Pronone® 10G) in August 1986 + disc trenching in May 1987; mechanical only (disc trenching, Rome disc) in May 1987. ***Experimental Design*** — Randomized complete block layout with three replicates of each block, treatments plots were 80 × 150 m. In each treatment plot, 20, 20-m^2 plots (aspen vigor, status, damage, height, diameter, age) and in mechanical treatments 10, 20-m^2 plots and/or 10 longitudinal transects (aspen root density, diameter, wounding, segmentation and suckering) were sampled. ***Measurements Taken*** — Fall 1985 to fall 1989, the above variables. **Results:** Preliminary, 2-year results show the lowest sucker density in two-pass Rome disc treatment followed by 4 kg Pronone® + Donaren and 4 kg Pronone® treatments (see below). Three-year results in 1990–91 and 5-year results in 1992–93.

Mean Density of Aspen Suckers 2 Years After Treatment

Treatment	Stems/ha
Control	56100
Pronone® 2 kg/ha a.i.	59350
Pronone® 4 kg/ha a.i.	41125
Pronone® 2 kg/ha a.i. with Donaren disc trenching	55425
Pronone® 4 kg/ha a.i. with Donaren disc trenching	33026
Donaren disc trenching	48800
Two-pass Rome disc	17067

Control of aspen development in areas designated for softwood production. Satellite test site C. 1987-P. **Location:** Peace River Forest, north of Hines Creek. **Methods:** ***Site History*** — Fire origin, white spruce–aspen, 120–150-year-old stand, harvested in the fall of 1988. **Methods:** ***Treatments*** — Single-tree applications of hexazinone (1 mL/2.5 cm dbh of 50% solution of Velpar® by punch and fill method and solid pellet by Swedish dry notch method) and 2, 4-D (1 mL/3.0 cm dbh and 1 mL/1.5 cm dbh of Formula 40) in June 1987. ***Experimental Design*** — Randomized complete block layout with four replicates of each block, treatment plots are 60 × 70 m. ***Measurements Taken*** — Crown mortality of aspen trees in the summer of 1988. **Results:** The punch and fill treatments of 1 mL/1.5 cm dbh Formula 40 and 1 mL/5.0 cm dbh Velpar® showed the highest crown mortality 1 year after application (see below). Three-year results on aspen suckering in 1991–92, 5-year results in 1994–95.

Mean Crown Mortality of Aspen Trees 1 Year After Treatment

Treatment	% Crown Mortality
Control	15
Swedish Dry Notch Method a.i. hexazinone Dosage: 1 tablet/5 cm dbh	7
Punch and Fill - Formula 40 a.i. 2,4-D (33% solution) Dosage: 1 mL/1.5 cm dbh	89
Punch and Fill - Formula 40 a.i. 2,4-D (33% solution) Dosage: 1 mL/3.0 cm dbh	57
Punch and Fill - Velpar® a.i. hexazinone Dosage: 1 mL/5.0 cm dbh	85

(Forestry Canada, Northwest Region, Edmonton, Alberta)

NAVRATIL, S.; Hayward R. Control of aspen development in areas designated for softwood production II. Satellite test site A. 1986-P. **Objectives:** To assess effects of chemical and mechanical site preparation and release treatments on density and growth of aspen and balsam poplar regeneration and post-planting performance of white spruce. **Location:** Lac La Biche Forest, Calling Lake District, Alberta. **Methods:** ***Site History*** — Aspen/white spruce stand damaged by a tornado was salvage logged and debris piled in the winter of 1985/86. ***Soils*** — Sandy loam to sandy clay, Orthic Gray Luvisol. ***Treatments*** — Applied in the fall of 1980, Velpar® 3 kg/ha a.i. application with backpack sprayer and extended boom, double pass Rome disc, Marttiini, straight blade, Marttiini + release, and control. Planted with 3–0 white spruce in May 1987. ***Experimental Design*** — Randomized complete block layout with four replicates of each block, treatment plots are 42.5 × 50 m 20, 20-m^2 plots for pre- and post-treatment assessments of aspen regeneration in each treatment plot. ***Measurements Taken*** — Summer 1986 to summer 1989, aspen vigor, damage, status, height, diameter, age, crop tree height, and overtopping. **Results:** Three-year results in 1989–90, 5-year results in 1991–92.

Satellite test site B. 1987-P. **Location:** Peace River Forest, Weberville, 50 km north of Peace River, Alberta. **Methods:** ***Site History*** — Aspen stand, approx. 65 years old. ***Soils*** — Clay soil, Orthic Gray Luvisol. ***Treatments*** — Single tree treatments with a.i. of glyphosate (Hack and squirt-Vision®; Gel-Cap®; Carbopaste), a.i. of hexazinone (hack and squirt-Velpar®, Swedish Dry Notch-Tablet) and pre-harvest spotgun application of Velpar® at 3 kg/ha a.i. in June 1987, post harvest one pass, two passes and two passes separated by time Rome disc treatments in the summer of 1988 and control. Planted with container white spruce in August 1988. ***Experimental Design*** — Randomized complete block layout with four replicates of each block, treatment plots 42.5 × 50 m; 20, 20-m^2 plots for assessment of aspen regeneration and crop trees in each treatment plot. ***Measurements Taken*** — Crown mortality of aspen parent trees in fall 1987; aspen sucker vigor, height, diameter, age, crop tree vigor, and overtopping in 1989. **Results:** Three-year results in 1990–91, 5-year results in 1992–93. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

SIDDERS, D. White spruce seedling response to various silviculture treatment combinations in the Saskatchewan eastern mixedwoods. 1989-P. **Objective:** To apply varying vegetation management techniques in the site preparation and early release stages of a silviculture prescription to enhance white spruce seedling establishment. **Location:** 80 km east of Carrot River on the Red Earth Indian Reserve, boreal mixedwoods in the Manitoba Lowlands ecoregion. **Method:** ***Site History*** — Softwood clearcut in 1987 leaving aspen as residual (approx. 50% crown closure), 90–100 years at 25 m in height. ***Treatment Area 1*** — Pre-site prepared in the winter of 1987 using a shearblade creating 4-m strips in the residual aspen and removing approx. 12 cm (of 15) of humus. A secondary treatment of powered disc trenching followed in the spring of 1988 with 3–0 white spruce bareroot hot-planted on completion. The white spruce was released in the late summer of 1989 from aspen and brush competition in two manners: (1) broadcast ground application of Vision® at 6 L in a 220-L solution; and (2) mechanical release using a high-speed mulcher. ***Treatment Area 2*** — Site prepared in the fall of 1988 with a powered disc trencher. In April of 1989, Velpar® L was applied selectively (trenches only) at a rate of 18 L/ha in a 220-L solution, with 3-0 white spruce bareroot planted 3 weeks following the application of Velpar®. ***Experimental Design*** — Spit-strip block design with 25 seedlings sampled in each of two replications (50 × 2 m) per treatment, four treatments in all. Treatment samples include: (1) control—double mechanical site prep. and plant; (2) double mechanical site preparation, plant and release with Vision®; (3) double mechanical site preparation, plant and mechanical release with high speed mulcher; and (4) powered trenching, Velpar® application and plant. ***Measurements*** — Crop tree (white spruce) height, diameter, form, and condition; competition species type and density. **(Forestry Canada, Saskatchewan District Office, Prince Albert, Saskatchewan)**

SIDDERS, D.; Navratil, S. Mechanical release of white spruce from trembling aspen using a high-speed mulcher. 1989-P. **Objectives:** To assess the response of young growth trembling aspen to a mechanical release cutting, and to assess the white spruce crop tree response resulting from the release. **Location:** 82 km north of Prince Albert on the Weyerhaeuser F.M.L.A., boreal mixedwood ecoregion. **Methods:** ***Site History*** — Softwood clearcut in 1968 leaving aspen as residual (approx. 40% crown closure), 80–85 years old and 20 m tall. Site prepared in 1983 using the blade/window method and was planted to 3-0 white spruce in 1984 at 2000 stems/ha. In 1989 (year 6) pre-assessments indicate an average of 8500 aspen stems/ha and 980 white spruce stems/ha were present on site with average heights of 3.4 and 0.52, respectively. ***Application Specifications*** — The Seppi-M brush mower was used to cut off the aspen just above the white spruce seedlings. The prime-mower, a Versitile tractor, straddled each planted row cutting 100% of the aspen stems within a treatment block. The treatments were completed at three different intervals in the growing season; at rapid early growth (June 19), the late growing season (August 30), and after freeze-up. ***Experimental Design*** — Randomized complete block layout with four replicates of each treatment (three timings, control). Treatment plots are approximately 20 × 50 m. In each treatment plot 20 crop trees and the nearest four aspen stems (per crop tree) were sampled. ***Measurements Taken*** — Stem height, diameter, spacing, and condition (vigor damage). **(Forestry Canada, Saskatchewan District Office, Prince Albert, Saskatchewan)**

SIDHU, S.S.; Feng, J. Environmental impact of mechanical and chemical treatments and chemical accountability of forestry herbicides. 1986-P. **Objectives:** To study the fate of selected herbicides in the forest ecosystem and evaluate their effects on community structure, composition, and dynamics. **Location:** 21 km south of P & G pulp mill, Grande Prairie, Alberta (Improvement district 16, NTS Big Mountain Creek sheet), mixedwood forest complex of Alberta. **Methods:** ***Site History*** — Clearcut in 1983, 80% aspen 70–80 years old and 18–24 m high with 20% lodgepole pine. ***Treatments*** — Hexazinone (Pronone® 10G), a.i. at 2 and 4 kg/ha in August 1986; hexazinone (Pronone® 10G) in August 1986 + disc trenching in May 1987; mechanical only (disc trenching, Rome disc) in May 1987. ***Planting*** — All treatment plots planted with Plug + 1 white spruce and container-grown lodgepole pine in May/June 1987. Competition at the treatment consisted primarily of dense aspen regrowth and reed grass. ***Soils*** — Solonetzic Gray Luvisols developed on lacustro-till, 25–60% OM in 4–15 cm-thick LH layer, moderately to imperfectly drained. ***Application Specifications*** — Granular hexazinone applied by isolair bucket attached to a helicopter flown at 33.5 m height and at 72.4 km/h. ***Experimental Design*** — Randomized complete block layout with three replicates of each block; treatment plots were 80 × 150 m with 30 × 100 m sampled for vegetation (30 plots, 5 × 5 m, for stem density and 120 plots, 1 × 1 m, for cover estimates in each treatment plot). ***Measurements Taken*** — Spring 1986 to fall 1988; stem density of woody species over 50 cm and cover of all species, residues in vegetation, soil, water, and sediments, vertical (in soil) and offsite movement of the herbicide, analytical methods for hexazinone in soil and vegetation, effects on ectomycorrhizal development in white spruce and lodgepole pine. **Results:** Available on distribution of granules by aerial and ground application, release of hexazinone under simulated and field conditions, residues in soil leachates, effects on vegetation (preliminary). **Conclusions:** In 1990–91. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

SIDHU, S.S.; Feng, J.; Feng, C. Environmental impact of Mechanical and Chemical treatments and Chemical Accountability of Forestry Herbicides. 1986-P. **Objectives:** To study the fate of hexazinone (applied as Pronone® 10G) in the forest ecosystem, evaluate its persistence and residue levels in some plant species. **Location:** 21 km south of P & G pulp mill, Grande Prairie, Alberta (Improvement district 16, NTS Big Mountain Creek sheet), mixedwood forest complex of Alberta. **Methods:** ***Site History*** — Clearcut in 1983, 80% 70–80 years old and 18–24-m aspen with 20% lodgepole pine. ***Treatments*** — Hexazinone (Pronone® 10G) at 2 and 4 kg/ha a.i. in August 1986; competition at the treatment consisted primarily of dense aspen regrowth and reed grass. ***Soils*** — Solonetzic Gray Luvisols developed on lacustro-till, 25–60% O.M. in 4–15-cm thick LH layer, moderately to imperfectly drained. ***Application Specifications*** — Granular hexazinone applied by isolair bucket attached to a helicopter flown at 33.5 m high and at 72.4 km/hour. ***Experimental Design*** — Randomized complete block layout with three replicates of each block, treatment plots were 80 × 150 m with 30 × 100 m sampled for vegetation (30, 5 × 5 m, plots for stem density and 120, 1 × 1 m, plots for cover estimates in each treatment plot). Sample collection and analysis - Spring 1987 to fall 1989. Bulk foliage and twig (20 sample points/plot, three replicates/rate) samples of several species collected at 30 days interval from May to September in 1987, July 1988, and July 1989. Samples kept frozen until hexazinone residues were determined by extraction, cleanup, and gas chromatography. Residue concentrations were reported as micrograms per gram on a dry weight basis. **Results:** Residue levels (±s) of hexazinone in three species from May to September 1987 are tabulated below:

	Rates of application and foliar concentration of hexazinone					
	4 kg/ha a.i.			2 kg/ha a.i.		
1987	Aspen	Calamagrostis	Aster	Aspen	Calamagrostis	Aster
				(ug/g)		
May	1.03±0.84	1.73±0.54	2.86±0.97	0.31±0.27	1.16±0.23	2.47±1.71
June	1.58±0.26	2.22±2.60	1.99±1.23	0.71±0.31	1.96±0.81	0.82±0.49
July	1.19±0.01	0.74±0.35	0.78±1.01	0.77±0.22	0.43±0.31	2.56±0.83
August	0.14±0.25	No Sample	0.17±0.30	<0.05	0.26±0.16	0.24±0.01
Sept.	0.04±0.06	No Sample	0.81±0.22	<0.05	0.35±0.26	0.53±0.10
All time maximum	1.87	5.16	3.43	1.01	2.67	4.43

Conclusions: The time at which peak concentrations of residues occurred varied among species, sites, and with degree of damage to foliage at collection. In general, residues decreased from spring to fall and with time since application. A preliminary assessment showed that in general the level of residues in foliage and twigs would not harm the wildlife consumers. A critical evaluation of residue data in relation to species preference of consumers, daily consumption rates, and time of the year a species is consumed is still needed. **(Forestry Canada, Northwest Region, Edmonton, Alberta)**

Chapter 8. Pacific and Yukon Region Summaries

DORWORTH, C.E. Biological control of forest weeds. 1986-P. **Objectives:** To identify forest weed problems that are amenable to control approaches that incorporate biological control agents, to identify those agents potentially most successful for use in constraining growth of forest weeds, and to develop technology for use of bioagents to such a point, and with such industrial potential, that it can be transferred to an appropriate production and marketing agent. Simultaneously, information relating to weed biocontrol is presented to clients and other groups to promote public awareness of the potential uses for biological control. **Location:** Primary research areas are southern Vancouver Island and the Peace River area of northern interior British Columbia. Current research sites on Vancouver Island include the Sarita and Shawnigan Licenses (MacMillan Bloedel) with reference to salal, and the recent Western Forests Products replant area along the Sombrio River from Highway 14 to the ocean with respect to fireweed. An area between Victoria and Duncan (Cobble Hill) has been secured for establishment of a provenance arboretum for alder, salal, and perhaps fireweed and for inoculations of red alder. Research to control bigleaf maple occurs on CIP land near Mesachi Lake. Other research is conducted near Victoria and in the PFC greenhouse. **Methods:** ***Experimental Design*** — Crop tree–weed problems, many of which are disclosed by FRDA studies or from the forest industry, are first evaluated through immediate examination of natural situations, perusal of federal and provincial reports, or cooperation with forest managers and forestry research personnel, to determine those amenable to solution by means of biocontrol agents. Diseased weeds are collected and the associated microorganisms are identified, cultured, and reinoculated onto healthy weeds in the greenhouse or into tissue cultures (1988 projected). Potentially useful bioagents are then inoculated onto or into appropriate weed species in the field for intensified testing. Simultaneously, a variety of means are tested to weaken the target weeds so that they can be more easily infected and colonized by microorganisms selectively. Diseased examples of the host plants selected for primary attention (mostly bigleaf maple, red alder, fireweed, and salal) were treated by standard microbiological isolation methods and the fungi obtained thereby were purified (brought to the point of axenic culture), characterized, placed in semipermanent storage for referral, and tested on the original target plants by various methods. Only native bioagents will be dispersed into the forest or onto experimental plots, and weed growth constraint will depend at least partly on new technology designed to predispose the hosts to maximum damage during the course of the host–pathogen interaction; some FRDA studies are contributing to the success of this research. ***Measurements Taken*** — Most experiments are of insufficient maturity to evaluate as yet. Measurements will eventually focus on elements of plant (weed) growth that are responsible for competitiveness of each weed species with respect to the desired crop plants (usually conifers). Further efforts on development of somoclonal lines of target host species for laboratory inoculation will be done to provide a rapid assay of bioagents and provide a safe site for comparative inoculations with exotic bioagents. **Results:** Results after 1 year are good regarding study initiation and laboratory setup and trivial regarding specific experimental results to date. **Conclusions:** Initial host plant responses are sufficient to warrant continuation of the work. Initial efforts have enabled workers to develop methods for this new work (this is the only full-scale forest weed mycoherbicide project in North America), and focus attention where best results might be achieved. **(Forestry Canada, Pacific and Yukon Region, British Columbia)**

HOLMSEN, S.D.; Whitehead,R.J. An evaluation of cost-effectiveness of clearing-saw treatments for weeding young shrub-dominated conifer plantations - Phase I: Cost, productivity, and crop damage. 1987. **Objectives:** To obtain estimates for cost, worker productivity, and accidental crop damage at time of treatment and to compare productivity of three cutting attachments. **Location:** Redfish Creek, 25 km east of Nelson, British Columbia, in a submesic association of the Lower Columbia-Kootenay moist southern interior cedar-hemlock biogeoclimatic subzone (ICHa1(03)). **Methods:** ***Site History*** — Ponderosa pine-Douglas-fir seed trees cut in 1981–83, with portions prepared by controlled underburns in 1984 and 1985 and spot-planted as required. The study area includes a mixed stand of planted ponderosa pine, western larch, and natural Douglas-fir and grand fir. ***Experimental Design*** — Fifty-four treatment units, each 16.7 × 25 m, were arranged in a factorial design (three vegetation types × 3 blade types × 2 operators) replicated three times. ***Measurements taken*** — Time and motion measurements were taken in each treatment unit. The 308 conifer seedlings were tagged before treatment and assessed pre- and post-treatment for condition and overtopping status. **Results:** Averaged over all vegetation types and blade types, worker productivity was 0.025 ha per productive hour (range 0.023 – 0.030); extrapolation to an 8-hour day with 80% utilization of time yielded an average of 6.3 worker-days per hectare. Average treatment cost was $775/ha, based on saw and operator costs of $15.40/h. Significantly higher productivity during actual clearing time was obtained with the MULTI 300 blade in smaller-stem-size vegetation. Although the MAXI 200 was slower overall, it was the only blade tested that was suited for stems over 2 cm in diameter. Nearly one in five crop trees assessed had damage attributed to treatment. Frequency of direct saw damage was related to visibility of the seedling within the shrub complex; less damage was noted on trees with projecting leaders than on overtopped stems. Results are published as FERIC Special Report No. SR-52 and as Canada/B.C. FRDA Research Report No. 028. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

OSWALD, E.T. Forest vegetation ecology. 1988-P. **Objective:** To elucidate the effective differences between summer and winter logging for enhancing the establishment and growth of commercial tree species in competitive environments. **Location:** In the moist Engelmann spruce–subalpine fir (ESSFc) biogeoclimatic subzone of Skelly Creek, northeast of Creston, in the Nelson Forest Region, southeastern British Columbia. **Methods:** ***Site History*** — The study area consists of a mature Engelmann spruce and subalpine fir stand supporting an undergrowth of false azalea, white-flowered rhododendron, and black blueberry on a north aspect. Part of the slope was scheduled for summer logging and part for winter logging. ***Soils*** — A Brunisol with mostly a sandy loam texture derived from granite interfaced with many large stones and boulders. ***Experimental Design*** — Before logging, two base lines were laid out across each block and 20 line-intercepts 10 m in length were randomly established in each block. Five 2 × 5 dm plots are positioned along the transect. The line-intercepts were marked for relocation after logging and prescribed burning. Five seedlings will be selected along each transect for measurement following planting. Microloggers will be used for obtaining climatic data. ***Measurements Taken*** — The height and cover of shrubs, the cover of trees, and the number and cover of nonwoody species were recorded before logging. Similar measurements will resume following prescribed burning. A micrologger was set up in the adjacent forest and soil and air temperatures and relative humidy are recorded. **Results:** The stand scheduled for summer logging was harvested during late August of 1988; the stand scheduled for winter logging is still uncut, now scheduled for winter of 1989–90. The summer logged area is being held from burning until the second area is cut so that both can be burned at the same time, presumably during the autumn of 1990. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

OSWALD, E.T. Vegetation succession following NSR rehabilitation trials. 1986-P. **Objective:** To elucidate the effect of nonchemical techniques for enhancing the establishment and growth of commercial tree species in competitive environments. **Location:** The moist Engelmann spruce-subalpine fir (ESSFc) biogeoclimatic subzone at Glenogle Creek east of Golden, British Columbia, Nelson Forest Region. **Methods:** ***Site History*** — The site was logged in the early 1970s, burned, and planted, but survival was poor to nonexistent creating NSR conditions. In early 1986 scarification trials were conducted using different techniques, which included V-plow, brush blade, and dip and dive, either parallel or perpendicular to the slope. Some more recently logged sites were broadcast burnt in the fall of 1985. All sites were planted with 313, 2+0 Engelmann spruce in 1986. ***Soils*** — Gravelly silt loams influenced by alpine glaciation, mostly Brunisols. ***Experimental Design*** — Blocks with representative scarification techniques of each type were selected and two base lines were established across the block. Line-intercepts, mostly 10 m in length and 15 per block, were randomly located along the base lines for measuring the height and cover of woody species. Along each line-intercept, five 2 × 5 dm plots were used for measuring the cover of herbs, brophytes, and lichens. Five planted Engelmann spruce seedlings in close proximity to each line were also selected for measurement. The line-intercepts were located so as to measure the revegetation on both sides of the scarified tack. In one burn, four line-intercepts were located at each sample site, one on the side-cast, one on the skid line center, one on the up-hill side, and one on the burn (the skid lines were made with a blade). Microloggers were established at two elevations. ***Measurements Taken*** -- The height and cover of woody plants and cover and number of nonwoody plants were measured by species annually. The total height, leader length, and basal diameter of each seedling was also measured. This year, 1990 will be the fifth year, after which meaurements will be made at 5-year intervals. Air and soil temperature, soil moisture, precipitation, relative humidity, solar radiation, and wind speed are recorded with microloggers. **Results:** All scarification techniques removed the vegetation, including root systems, and surface organic matter most often leaving exposed subsoil material, thus nearly all revegetation on the scarified tracts was from seed. The prescribed fires did not kill the root systems of shrubs or rhizometous species, and these species resumed growth mostly the following year. Fireweed was the most prevalent invader, and was dominant after 2 or 3 years; it grew best on the side-cast, then the burned areas, with the center and up-hill part of the tract about the same. Seedling growth was similar, although those in the burn were initially better than on the side-cast. Seedlings planted in wet sites with high contents of organic matter did very poorly, as did those on compacted subsoil. **Conclusions:** The 5th-year report will be prepared after the 1990 season. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

TAYLOR, S.W.; Hawkes, B.C. Prescribed fire behavior and impact prediction for the rehabilitation of backlog NSR land in northern interior B.C. 1986-P. Objectives: To assess the behavior and impact of operational prescribed burns over a range of burning conditions to provide information for prescription development and to monitor vegetation development following burning to extend the results of the companion study (Taylor et al.) described elsewhere in this report. **Methods:** ***Experimental Design*** — Case studies on three operational prescribed burns. Three prescribed fire impact plots were located on each site; 25 permanent vegetation assessment subplots were located in each fire impact plot. ***Measurements Taken*** — Fuel load and consumption and forest floor depth reduction were measured in the fire impact plots. Soil temperatures were measured during burning. The height and cover of each vascular plant species in the subplots was assessed before treatment and will be reassessed over the first three growing seasons following burning. **Site A: Location:** Seebach Creek, Prince George, British Columbia. ***Site History*** — Clearcut in 1981 and became NSR. Vision® herbicide applied aerially at 2.4 kg/ha in late July 1988. Broadcast burning carried out in May 1989. Vegetation present before treatment was predominantly bracken fern, lady fern, thimbleberry, and fireweed. **Site B: Location:** Pinkut Lake, Burns Lake, British Columbia. ***Site History*** — Selectively logged in 1960 leaving a residual stand of predominantly subalpine fir. Salvage logged in the winter of 1988–89 and broadcast burned in September 1989. Vegetation competition before treatment consisted of scattered green alder. **Site C: Location:** Peters Creek, Quesnel, British Columbia. ***Site History*** — Selectively logged in the 1960s leaving a residual stand of predominantly subalpine fir. The residual stand was slashed in 1986. Vision® was applied aerially and by backpack in June of 1989. Broadcast burning was carried out in September 1989. Vegetation competition before treatment was mainly white rhododendron and fireweed. **Results:** Interim results of the fire impact assessments will be reported in a Canada/British Columbia FRDA Research Report in March 1990. **Conclusions:** N/A. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

TAYLOR, S.W.; Hawkes, B.C.; Silversides, R.H.; Weber, M.G. Prescribed fire effects and efficacy in the treatment of backlog NSR land in northern interior B.C. 1987-P. **Objectives:** To examine and compare the effects of site preparation treatments using prescribed fire for backlog NSR land on microclimate, soil nutrient status, seedling establishment and vegetation competition. **Location:** Stony Lake, Prince George, British Columbia. **Methods:** ***Site History*** — Mature white spruce, subalpine fir stand was selectively logged in 1969–72 leaving fir residuals. Regeneration was not satisfactory, and the residual stand was slashed in 1986. Six site preparation treatment combinations were applied in the summer and fall of 1986 consisting of broadcast burning, brown and burning (herbicide spraying followed by broadcast burning), and windrowing, all with and without subsequent disc-trenching. Container grown PSB 313 white spruce and PSB 211 lodgepole pine were planted in May of 1987. The dominant plant species before treatment were black twinberry, thimbleberry, and fireweed. ***Soils*** — Deep, moderately well drained and medium textured of till origin, with an 8-cm organic layer. ***Application Specifications*** — An International TD15C crawler tractor with a brush blade was used for windrowing in June 1986; windrows were burned in November. Vision® herbicide was applied at a.i. 2.4 kg/ha in about 200 L solution by backpack in late June 1986. Prescribed burning was carried out September 7, 1986; codes and indexes of the Canadian Forest Fire Weather Index System were FFMC 90 DMC 25 DC 235. An aerial drip torch was used for ignition. Disc-trenching was carried out in October 1987 with a TTS Delta powered disc trencher. ***Experimental Design*** — Primary site preparation treatments were applied in a randomized complete block with three replications of each block; tree species and disc-trenching were applied in a split-split plot layout. There were 36, 0.1-ha permanent growth assessment plots containing 110 staked trees and ten 3-m diameter vegetation assessment subplots. ***Measurements Taken*** — Woody fuel load and consumption, forest floor depth reduction, and soil temperatures during burning were measured in the prescribed burn treatments. Soils were sampled for nutrient determination June 1986 before site preparation and May 1988 at time of planting. The height and percent cover of all vascular plant species was assessed in the vegetation subplots before treatment, and in the first 2 years following site preparation (July 1987, 1988, and 1989, respectively). Height and basal diameter measurements of each tagged seedling, and destructive sampling of three additional seedlings per plot for biomass and nutrient content determinations were carried out in September 1988 and 1989. Continuous measurements of site climate variables and soil temperature and moisture in the rooting zone were carried out in the 1988 and 1989 growing seasons. **Results:** (Preliminary) Control of fireweed and black twinberry was greatest in the brown and burn treatment in the first growing season; thimbleberry was less affected. Diameter, volume index, and needle and stemwood increment of the spruce and pine seedlings were also greater in the brown and burn treatment in the first growing season. Disc-trenching resulted in significant increase in seedling root and needle mass. There were no significant differences in seedling survival or height among treatments in the 1st year. **Conclusions:** The first two growing seasons results will be available in a Canada/B.C. FRDA Research Report in March 1990. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

WALL, R. E. Stump and frill treatments of red alder with pathogenic fungi to hasten mortality and prevent sprouting. 1987-P. **Objectives:** To apply and expand on findings regarding the use of *Chondrostereum purpureum* in eastern hardwoods and to control red alder on the Pacific coast. **Location:** Victoria and Sooke, British Columbia. **Methods:** ***Site History*** — Upland sites where dense growth of alder occupies a power line right-of-way (Victoria) and a Douglas fir plantation (Sooke) were chosen for stump and frill treatments, respectively. ***Experimental Design*** — All alder >5 cm dbh were numbered and 20 trees selected at random for each treatment. Treatment variables include fungi (three local isolates of *Chondrostereum purpureum* as well as other promising stem pathogens isolated from alder), formulation (intact plate cultures, oil slurries, macerated mycelia), and season. Efficacy measurements will consist of the extent of cambial necrosis from the point of inoculation (frill or stump surface), the development and mortality of stump sprouts, and the time interval between inoculation and crown mortality in the case of frill inoculations. **Results:** Mortality by July 30, 1989, of red alder frill-treated with oil slurries of *C. purpureum* (isolate 47):

Date of inoculation	% Mortality		
	Inoculated	Control*	Untreated**
April 30, 1988 (budbreak)	23	19	4
June 29, 1988 (early summer)	35	5	-
Oct. 6, 1988 (leaf senescence)	5	0	5
April 8, 1989 (pre-budbreak)	0	0	0

*Frills treated with sterile oil slurry.

**Frills untreated.

Conclusions: These preliminary data indicate that midsummer treatments may be effective. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

WALL, R.E.; Shamoun, S. Biological controls for Rubus spp. 1980-P. **Objective:** To find suitable biological controls for thimbleberry, wild raspberry, and other *Rubus* spp. that compete with commercial forest trees. **Locations:** Maritime Provinces and British Columbia. **Methods:** ***Experimental Design*** — Stands of wild *Rubus* have been examined for disease over wide areas and cultures of microorganisms isolated from diseased tissues. Plants have been inoculated with native microorganisms in growth chambers, greenhouses, and in replicated field plots. Simultaneously, stress treatments such as clipping and defoliation have been applied. **Results:** Work with raspberry in the Maritime Provinces indicated few microbial pathogens with bioherbicide potential. Weak pathogens frequently isolated were the fire blight bacterium (*Erwinia amylovora* [Burr.] Winslow et al.), and four fungi associated with mild leaf and shoot blights (*Gnomonia rubi* [Rehm] Winter, *Colletotrichum* sp., *Botrytis* sp. and *Phoma* sp.). These caused very little damage to inoculated plants. Most of the natural control occurring in wild raspberry appeared to be the result of virus diseases. The most conspicuous among the latter group was the raspberry leaf curl disease which appeared in most stands during the 1st year of development and caused >60% height reduction in affected plants. Rubus mosaic virus diseases were also noted in New Brunswick. An insect (*Elachiptera costata* [Loew]) was associated with a severe blighting of young canes. Clipping of 1st year growth to ground level during late June to mid July resulted in about 50% height reduction by the end of the growing season. , On thimbleberry in British Columbia, *Septoria* leaf spot, root rots associated with *Cylindrocarpon destructans* (Zinf.) Scholten, *Fusarium oxysporum* Schlecht, *Resinicium* sp. and *Naematoloma fasciculare* (Huds. ex Fr.) Kar. and galls caused by the insect *Diastrophus kinkaidii* Gillette have been collected and are being examined with respect to biological control. Effects of sublethal doses of herbicides as well as manual clipping and defoliation are being studied in relation to the effects of foliar and root pathogens. **Conclusions:** Biological controls can only be developed with advanced technology plus better understanding of the target species and the ecosystems in which they thrive. No pathogens of *Rubus* spp. with outstanding bioherbicide potential are yet evident but some may remain undiscovered. In wild raspberry in eastern Canada, the raspberry leaf curl virus already provides some control and means of enhancing the effectiveness of this aphid-borne virus may be found. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

WHITEHEAD, R.J. An evaluation of cost-effectiveness of clearing saw treatments for weeding young shrub-dominated conifer plantations - Phase II: Silvicultural efficacy. 1987-P. **Objectives:** To evaluate growth responses of crop trees and major competing species to three brushing intensities (not brushed, brushed once, and brushed annually). **Location:** Redfish Creek, 25 km east of Nelson, British Columbia, in a submesic association of the Lower Columbia–Kootenay moist southern interior cedar–hemlock biogeoclimatic subzone (ICHa1(03)). **Methods:** ***Site History*** — Ponderosa pine/Douglas-fir seed tree cut in 1981–83, with portions prepared by controlled underburns in 1984 and 1985 and spot-planted as required. The study area includes a mixed stand of planted ponderosa pine, western larch, and natural Douglas-fir and grand fir. ***Experimental Design*** — Nine treatment units (50 × 50 m) were established in a completely randomized design with three treatment levels (not brushed, brushed once, brushed annually). ***Measurements Taken*** —Pre-treatment, and 1, 2, 3, and 5 years post-treatment. Within each treatment unit, 30 crop trees are assessed for condition, free-growing status, and height and diameter growth; 20, 10-m^2 circular subplots are established for assessment of percentage cover and modal height of the major competitive complex, and percentage cover of each of the three major species present. Individuals of these three species are tagged for assessment of height and vigor. Changes in the composition and structure of the plant community are assessed by descriptive measures of cover abundance, distribution, and vigor in a central 20 × 20 m macroplot. **Results:** The trial was established in August 1987. An interim report, including second-growing-season results, will be available as a Canada/B.C. FRDA Research Report in March 1990. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

WHITEHEAD, R.J. Comparison of four treatment options for weeding shrub dominated spruce plantations. 1986-P. **Objectives:** To determine and compare crop tree growth response, growth response of major target species, and changes in plant community composition and stucture following four treatment options. **Location:** The Bush River drainage, 110 km north of Golden, British Columbia, moist interior cedar–hemlock subzone (ICHa2[04]). **Methods:** ***Site History*** — The block was ground logged in winter 1981, broadcast burned in spring 1983, and planted to Englemann spruce 2+0 bareroot stock in spring 1984. By fall 1985, spruce were overtopped by a shrub/forb complex consisting primarily of thimbleberry, raspberry, and fireweed. ***Treatments*** — Two broadcast herbicide treatments (glyphosate at 1.8 kg/ha a.i. and 2,4-D amine at 3.0 kg/ha a.i.) were applied in water carrier at 40 L total solution/ha, using a CP-3 backpack sprayer. Husqvarna 165r clearing saws with Maxi 255 blades were used to clear all vegetation as close to ground level as practically achievable. All treatments were applied in mid-late August, 1986. ***Experimental Design*** — Randomized complete block with three replications, each treatment plot 60 m × 60 m square. Within each plot, 20, 10-m^2 circular subplots were established for measurement of target species response, and 30 spruce were tagged for assessment of crop growth response. Measurements were taken pretreatment, and at 1, 2, and 3 years post-treatment. **Results:** Trends in treatment effects are illustrated by changes in major complex above ground volume:

	Major Complex Above-Ground Volume			
	m^3/ha	% Change since 1986		
	1986	1987	1988	1989
Untreated	6061	-11 A*	- 6	-11 A
2,4-D amine	5792	-30 B	-16	-17 A
Manual brushing	5721	-25 B	- 7	-21 A
Glyphosate	4896	-80 C	-56	-60 B
P > F	0.08	0.002	0.06	0.003

*Means followed by the same letter within columns are not significantly different at 95% confidence level.

Glyphosate controlled all species well for 3 years, particularly thimbleberry, although ingress (primarily from seed) was rapid (2 years) for raspberry and fireweed. Any release achieved by 2,4-D amine or manual brushing was short-lived and of little consequence. Relative volume change for spruce since treatment was significantly higher in the glyphosate treated plots in 1988 ($P>F = 0.04$) and 1989 ($P>F = 0.02$). Next measurement is scheduled for 1991. **(Forestry Canada, Pacific and Yukon Region, Victoria, British Columbia)**

Chapter 9. Forestry Canada Vegetation Management Activity

The major objective of vegetation management is to provide a competitive advantage for desired forest tree species over other species of plants that may occupy the same sites. There are two approaches. One is to control the growth of or eliminate the undesirable competing species, and the other is to use techniques that would enhance the competitive ability of the tree species over the competing species. Combinations of these two approaches are also possible. It is rarely, if in fact ever, desirable to eliminate all plants that may compete with the designated crop tree because they are often beneficial to the establishment of the seedlings by providing protection, and they contribute to the site quality and nutrient regime through mineral cycling and soil stability.

The majority of vegetation management related projects within Forestry Canada involve the use of herbicides, and every establishment has at least some involvement with herbicides. Glyphosate (Roundup® or Vision®) is the most widely used herbicide, generally applied by a sprayer (aerially or back-pack), but the Northwest Region has tried it in the hack-and-squirt procedure. Although results are somewhat premature, apparently glyphosate, used as a spray, is effective in reducing competing vegetation, and is not detrimental to conifer seedlings if applied when the seedlings are in a dormant or hardened-off state. The results of use in the hack-and-squirt procedure were not revealed, but indications are that satisfactory reductions in root sprouts can be achieved. Hexazinone, either as liquid (Velpar®) or granular (Pronone® 10G), was the second most commonly used herbicide. The largest assortment of herbicides was used in the Maritimes, not only by the Maritimes Region, but also by the Forest Pest Management Institute which has several studies in the Maritimes. Some of these chemicals are detrimental to the seedlings, at least under the application techniques used, and thus one must be aware of the species affected and the end result desired from the use of herbicides.

At least some mechanical site preparation is done at every forestry center, but often only as a comparison or control with a test of herbicides, or as part of the harvesting procedure, rather than as a study in itself. Hand-cutting techniques are used for most small operations, although deep rototilling was used in the Maritimes for some situations. A variety of larger implements has been used by the Northwest and Pacific and Yukon Regions, and a Bracke scarifier was used by the Ontario Region and a crusher by the Forest Pest Management Institute in New Brunswick. The heavier machinery can effectively remove competing vegetation, including the root systems, but often also removes the top soil and organic matter creating a nutrient-poor medium into which seedlings are planted. Heavy machinery can also compact the soil, the extent of which depends on soil texture and moisture among other things, and is generally deleterious to the growth of seedlings, including those of competing species. Thus the planting site within the scarified area becomes critical. Hand-cutting and mechanical-shearing techniques usually remove the above-ground portion of competing plants and, depending on site conditions and competitors involved, may require repetitive treatment until the seedlings are well established.

Prescribed fire as a vegetation control procedure is being examined only in the Pacific and Yukon Region, and this primarily in the subalpine zone, even though prescribed burning following logging is practiced elsewhere. Slash fire is effective in removing the above-ground portion of competing woody plants, and makes the area easier to plant, but most woody species are capable of regeneration from root stalks. It is too early to tell wether the set-back of competing vegetation achieved by burning is sufficient to allow seedling growth to keep ahead of root stock development.

Examination of the timing of forest harvesting in relation to vegetation control is being examined at the Pacific and Yukon Region, but this study is just getting under way. A closer look at the timing of other site preparation events is also under way. The theory is that destructive events, such as brush removal, scalping, burning, and scarification, are more detrimental to the competing vegetation if the action is performed during the leaf flush and seed production phases of phenology, a time when there is a net loss of nutrients from the root systems. The use of herbicides in relation to plant phenology has been examined at the Forest Pest Management Institute. Herbicide efficacy depends on its absorption and the type of action it has on the host plant.

The study of biological control techniques for vegetation management is currently confined to the Pacific and Yukon Region. A variety of organisms is currently being examined, mostly through isolation of naturally occurring fungi and bacteria found to be deleterious to the growth of plants considered competitive to the designated crop species. Although some possible control organisms have been found, insufficient work has been done to prove their worthiness. Promising results are being obtained by using a combination of herbicide and micro-organism to control some undersirable species.

Most submitted summaries pertained to studies currently under way, thus results are usually not yet available. Even where some results are available, they pertain mostly to the immediate or short-term effect of the vegetation control technique. To fully examine the effectiveness of a technique for controlling competing vegetation, the study must continue at least until the seedlings reach the "free-to-grow" stage, and preferrably beyond that to the mature stand stage.

Even though Forestry Canada has a fairly active vegetation management research involvement across the nation, there are some aspects that require study. Some of the techniques being tested now also require testing in other situations and in different climatic regions. Because of the public concerns, it is becoming increasingly important to find vegetation control alternatives to the use of chemicals, and to some degree the use of prescribed burning. Due to the diversity of climatic conditions of forest land across Canada, the variations in competing species, and ecological differences in the desired tree species, it is unlikely that the same techniques can be used universally. The exceptions might be the use of chemicals that act directly on the vegetation. The following list indicates some of the avenues that might be examined for vegetation control procedures, excluding those based on chemicals that are already being widely studied:

1) Larger sizes of planting stock. This is applicable only where seedlings are planted. There are different-sized plugs available, and different-sized plants for bare-root planting can be generated. Perhaps larger plants will give a competitive edge to the crop tree against the competing species. This must be examined for each crop tree species on different sites and in the light of seedling production and planting economics.

2) Timing of planting. This will vary with ecoclimatic subregion or site, particularly in relation to available moisture, and will likely depend also on other site preparation procedures that may be used. Timing can be viewed in relation to time of year or in terms of time after logging. Hot-lifted stock planted in early summer in moist or wet environments has several advantages over other planting times during the year. In some cases, a few years may elapse between forest removal and replanting, and this will most often necessitate some site preparation procedure before planting. However, on some sites there may be a benefit gained by delaying planting up to 2 years.

3) Timing of forest harvesting. Under certain conditions, such as unfrozen and wet soil, the effect of operating heavy logging equipment on the ground can be drastically different than operating on frozen or dry soil. Under the former conditions, the churning achieved by the harvesting procedure can have a deleterious effect on the remaining vegetation, but at the same time can compact the soil making an inhospitable planting site.

4) Forest harvesting procedure. High-lead logging could be examined as an alternative to skid-logging under various conditions where sites are sensitive to degradation. Clearcutting vs. selective harvesting might be examined in a variety of stand compositions and site conditions. We must determine whether adequate regeneration of the desired tree species can be acheived through repeated selective removal of larger trees.

5) Mechanical site preparation. There are many forms of mechanical site preparation that need further examination for effectiveness in forming a favorable planting site without degrading the site at the same time. The prescription of machinery must consider site characteristics. Such factors as steepness of slope, stone size and content, and soil moisture status will influence the type of machinery used. Cost effectiveness must be considered as well. Perhaps a machine that breaks up and compresses slash, but at the same time exposes patches of mineral soil needs to be developed.

6) Manual vegetation control. This normally involves the use of brush saws for removing the above-ground portion of woody plants. Trials have been done at different times after planting, and sometimes are repetitive. Further trials in relation to shrub phenology could be conducted. In general, the operation is rated as being labor intensive, hazardous, uneconomical, and inadequate to achieve the desired level of control, but considering site conditions is essential. Under some

conditions, large screefs at the time of planting may be adequate; there are machines that facilitate screefing.

7) Heavy fertilization. Currently there is only one study by Forestry Canada, this being in Newfoundland, that is testing the effects of fertilizers for controlling vegetation. This study is just getting under way and no results on which any comments can be made are available yet. It can be anticipated that prescriptions for fertilizer use will be site-specific and will depend on the plant species present and the site characteristics.

8) Prescribed burning. Fuel load and moisture conditions (often related to the amount of organic matter present) at time of burn can greatly influence the effect of the burn on the site. Hot burns, arising from dry fuel, reach deeper into the root systems of potential competing plants, usually burn with less smoke being evolved (also related to atmospheric conditions at the time of burn), and may provide more mineral surface for planting, but are more difficult to control and may remove more soil nutrients. Control of smoke emissions must be of paramount concern, and burning should not be done where alternatives are available.

9) Biological control. This area of vegetation management is wide open in terms of research. What is needed are organisms specific to the control of a particular species that can be operationally propagated and used without causing any other environmental impact. Public concerns pertaining to biological control organisms are very similar to the use of chemicals, thus any vegetation control techniques must be very well tested and used with considerable caution. Currently some success has been achieved using a sublethal dose of herbicide to reduce the plant vigor and make it more susceptible to further degradation by micro-organisms.

The following table is provided to assist in locating the user of a particular type of vegetation control technique. The senior authors are in alphabetical order within a region and the regions are positioned in the same order as in the text. The following abbreviations are used for the regions: NL = Newfoundland and Labrador, M = Maritimes, Q = Quebec, O = Ontario, FPMI = Forest Pest Management Institute, UoT = University of Toronto, MDO = Manitoba District Office, NW = Northwest, SDO = Saskatchewan District Office, PY = Pacific and Yukon. The date of the first treatment is given followed by the crop tree species and understory type. The more commonly used herbicides are listed separately; the "other" category includes several, mostly unregistered chemicals, or chemicals not specifically used as herbicides. Scarification is grouped into three broad categories, plus the "other" group. Brushcutting includes both mechanical and manual equipment used to shear off the vegetation at or above ground level, mostly used for woody plants. Fertilizer, burning, and biological control are in separate columns.

The Vegetation Management Working Group intends to update these summaries periodically adding new studies as they develop and recording or publishing results and conclusions when available. Comparable summaries from the work being done by other agencies will also be included. The procedure for submitting summaries is provided in Appendix E, and we encourage your participation in the program. A computer data base accessible by keywords will be adopted or developed to handle the volume of summaries efficiently. Because this procedure is in its infancy, any comments pertaining to it would be appreciated.

Table 1. Summary of vegetation management techniques used in research by Forestry Canada personnel. Cont'd

Author	Region	1st Treatment	Crop species	Understory type	Herbicide						Scarify				Brushcut		Fertilizer	Burning	Biological
					Glyphosate	245t +24d	Triclopyr	Picloram	Hexazinone	Others	Disc	Blade	Rototill	Others	Mechanical	Manual			
Richardson	NL	1978	Softwood	Brush	•	•	•								•				
Richardson	NL	1975	xS, jP	Alder		•		•							•	•			
Titus	NL	1989	xS, xP, xL	Brush			•		•		•						•		
Lanteigne	M	1974	bF	Brush		•													
Lanteigne	M		bS, jP	Vari						•									
Lanteigne	M	1985	bS	Vari					•										
Lanteigne	M	1984	jP							•									
Lanteigne	M	1984	bS							•									
Lanteigne	M	1986		Grass						•									
Lanteigne	M	1984		Grass						•									
Lanteigne	M	1984	wS	Grass						•									
Lanteigne	M	1986	bS, wS							•									
Lanteigne	M	1986	bS, wS, jP							•									
Lanteigne	M	1986	bS, rS							•									
Lanteigne	M	1986	bF, eL							•									
Lanteigne	M	1987	bS, rS							•									
Salonius	M	1985	Softwood	Vari	•														
Salonius	M	1981	jP, wbrS	Vari									•						
Wall	M	1985		Sprou														•	
Wall	M	1986		Sprou														•	
Delisle	Q	1984	jP, sP	Shrub	•						•								
Roberge	Q	1964	Softwood	Shrub												•			
Ung	Q	1988	rO, nS	Shrub												•			
Roberts	O		Softwood	Vari		•													
Sutton	O	1978	wS						•										
Sutton	O	1982	bS, jP	Brush						•									
Wood	O	1982	bS	Brush	•							•			•				
Wood	O		bS	Brush					•			•			•				
Wood	O	1986	bS	Vari					•					•					
Wood	O	1984	jP	Vari	•						•								
Kreutzweiser	FPMI	1984		Water	•														
Payne	FPMI	1984		Water	•														
Pitt	FPMI	1987	bS	Vari					•										
Pitt	FPMI	1987	bS	Vari					•										
Pitt	FPMI	1984	wS	Shrub					•					•					
Prasad	FPMI	1982	rP	Vari	•		•		•	•									
Prasad	FPMI	1985		Vari	•														
Prasad	FPMI	1986		Shrub	•					•									
Prasad	FPMI	1985	rP	Shrub					•										
Prasad	FPMI	1985			-----------	---------	-------	------	sprayers	and	droplet	size	--------	---------	-----------	---------			
Reynolds	FPMI	1984	wS	Vari					•					•					
Reynolds	FPMI	1984	bS	Shrub					•					•					

Table 1. Concluded

Author	Region	1st Treat-ment	Crop species	Under-story type	Herbicide						Scarify				Brushcut		Fertil-izer	Burn-ing	Bio-logical
					Glypho-sate	245t +24d	Triclo-pyr	Piclo-ram	Hexa-zinone	Others	Disc	Blade	Rototill	Others	Mechanical	Manual			
Reynolds	FPMI	1986	bS	Vari					•					•					
Reynolds	FPMI	1986	bS	Vari						•				•					
Reynolds	FPMI	1986	bS	Vari					•					•					
Reynolds	FPMI	1986	bS	Vari						•				•					
Reynolds	FPMI	1986	bS	Vari						•				•					
Reynolds	FPMI	1986	bS	Vari					•					•					
Reynolds	FPMI	1986	bS	Vari					•	•				•					
Reynolds	FPMI	1986	bS	Vari					•					•					
Reynolds	FPMI	1986	bS	Vari						•				•					
Reynolds	FPMI	1984	sS	Shrub	•							•					•		
Roy	UoT	1985							•										
Ball	MDO	1987	bS,wS	Shrub							•	•			•				
Ball	MDO	1962	wS	Shrub								•				•			
Bruce	NW	1986	wS, 1P	Aspen					•		•					•			
Corns	NW	1987	wS	Grass												---------	mulch	-------	--------
Feng	NW	1984	wS	Aspen					•	•							•		
Feng	NW	1986							•										
Feng	NW	1986		Aspen					•										
Feng	NW	1984							•										
Feng	NW	1986		Aspen					•										
Feng	NW	1989	wS	Vari					•		•								
Feng	NW	1988	wS, 1P	Vari					•										
Feng	NW	1984	sS	Brush	•														
Gardner	SDO	1986	bS, jP	Aspen	•											---------	girdle	-------	------
Maynard	NW	1986	1P	Vari					•										
Navratil	NW	1986	Softwood	Aspen					•		•								
Sidders	SDO	1989	wS	Aspen	•				•		•			•	•				
Sidders	SDO	1989	wS	Aspen											•				
Sidhu	NW	1986	wS, 1P	Aspen					•		•								
Sidhu	NW	1986	Softwood	Aspen					•										
Dorworth	PY	1986	Softwood	Shrub														•	
Holmsen	PY	1987	Softwood	Shrub												•			
Oswald	PY	1986	eS	Shrub								•					•		
Oswald	PY	1988	eS	Shrub													•		
Prasad	PY	1983	rP	Aspen					•										
Taylor	PY	1987	wS, 1P	Shrub	•						•	•					•		
Taylor	PY	1986	Softwood	Shrub	•												•		
Wall	PY	1987		Alder														•	
Wall	PY	1980	Softwood	Rubus														•	
Whitehead	PY	1986	eS	Shrub	•											•	•		
Whitehead	PY	1987	Softwood	Brush												•	•		

Appendix A. Common and Scientific Names of Plants

Coniferous Trees

cedar (eastern white cedar)	*Thuja occidentalis*
western red	*Thuja plicata*
Douglas-fir	*Pseudotsuga menziesii*
fir	*Abies* sp.
alpine	*Abies lasiocarpa*
amabilis	*Abies amabilis*
balsam	*Abies balsamea*
grand	*Abies grandis*
hemlock, western	*Tsuga heterophylla*
larch	*Larix* sp.
eastern (tamarack)	*Larix laricina*
European	*Larix decidua*
western	*Larix occidentalis*
pine	*Pinus* sp.
jack	*Pinus banksiana*
lodgepole	*Pinus contorta*
ponderosa	*Pinus ponderosa*
red	*Pinus resinosa*
Scots	*Pinus sylvestris*
spruce	*Picea* sp.
black	*Picea mariana*
Engelmann	*Picea engelmannii*
Norway	*Picea abies*
red	*Picea rubens*
Sitka	*Picea sitchensis*
white	*Picea glauca*

Deciduous Trees

alder, red	*Alnus rubra*
ash	*Fraxinus* sp.
black	*Fraxinus nigra*
white	*Fraxinus americana*
aspen (trembling aspen)	*Populus tremuloides*
largetooth	*Populus grandidentata*
beech (American beech)	*Fagus grandifolia*
birch	*Betula* sp.
paper/white	*Betula papyrifera*
yellow	*B. alleghaniensis (B.lutea)*
cottonwood, black	*Populus trichocarpa*
maple	*Acer* sp.
bigleaf	*Acer macrophyllum*
Manitoba	*Acer negundo*
mountain	*Acer spicatum*
red	*Acer rubrum*
striped	*Acer pensylvanicum*
sugar	*Acer saccharum*
oak, red	*Quercus rubra*
poplar, balsam	*Populus balsamifera*

Shrubs

alders	*Alnus* sp.
azalea, false	*Menziesia ferruginea*
blueberries	*Vaccinium* sp.
blueberry, black	*Vaccinium membranaceum*
cherry, pin	*Prunus pensylvanica*
elderberry	*Sambucus* sp.
hazel	*Corylus* sp.
beaked	*Corylus rostrata*
hobblebush	*Viburnum alnifolium*
huckleberry, red	*Vaccinium parvifolium*
raspberry	*Rubus* sp.
red	*Rubus idaeus*
wild	*Rubus* sp.
rhododendron, white-flowered	*Rhododendron albiflorum*
salal	*Gaultheria shallon*
salmonberry	*Rubus spectabilis*
sheep-laurel	*Kalmia angustifolia*
thimbleberry	*Rubus parviflorus*

Herbs

aster, acuminate	*Aster acuminatus*
bracken	*Pteridium aquilinum*
fern, deer	*Blechnum spicant*
lady	*Athyrium filix-femina*
sword	*Polystichum munitum*
fireweed	*Epilobium angustifolium*
grass, reed	*Calamagrostis* sp.
strawberry	*Fragaria* sp.

Appendix B. Publications by Forestry Canada

A. Journal Publications and Information Reports

A-1 Chakravarty, P.; Sidhu, S.S. 1987. Effect of glyphosate, hexazinone, and triclopyr on invitro growth of five species of ectomycorrhizal fungi. Eur. J.For. Path. 17:204-210.

A-2 Chakravarty, P.; Sidhu, S.S. 1987. Effect of hexazinone (Pronone 5G) on the seedling growth and mycorrhizal incidence of Pinus contorta Dougl. var. latifolia Engelm and Picea glauca Voss. Eur. J. For. Path. 17:282-291.

A-3 Dorworth, C.E. 1989. Mycoherbicides in forest weed control. In Sue Watts, Ed. FRDA Report 059 UBC INFORMS Newsletter 2:3-4, Dept. For. Sci., Univ. British Columbia.

A-4 Dorworth, C.E. 1989. Mycoherbicides for forest weed biocontrol - the PFC enhancement process. Journal - Integrated Vegetation Management Assoc. of British Columbia 18:15-17.

A-5 Dorworth, C.E. 1989. Mycoherbicides in forest weed control. Biocontrol News 2:37-40.

A-6 Feng, J.C. 1987. Persistence, mobility and degradation of hexazinone in forest silt loam soils. J. Environ. Sci. Health B22: 221-233.

A-7 Feng, J.C.; Ehrentraut, G.B.; Drew, T.J. 1989. Depostion of hexazinone from a logarithmic sprayer. J. Environ. Sci. Health B24:525-538.

A-8 Feng, J.; Feng, C. 1988. Determination of hexazinone residues and their fate in a New Brunswick forest. FPM-X-81. 15 p. + appendix.

A-9 Feng, J.C.; Feng, C.C.; Sidhu, S.S. 1989. Determination of hexazinone residues and its release from a granular formulation under forest conditions. Can. J. For. Res. 19:378-381.

A-10 Feng, J.C.; Klassen, H.D. 1986. Forestry field and laboratory manual for herbicide residue sampling, sample processing and reporting. FPM-X-72. 38 p.

A-11 Feng, J.C.; Navratil, S. 1990. Sampling for zero-time hexazinone residues in forest soils for dissipation study. Submitted to Can. J. For. Res. in press.

A-12 Feng, J.C.; Sidhu, S.S. 1989. Distribution of blank hexazinone granules from aerial and ground applicators. Weed Technol. 3:275-281.

A-13 Feng, J.C.; Sidhu, S.S.; Feng, C.C.; Servant V. 1989. Hexazinone residues and dissipation in soil leachates. J. Environ. Sci. Health B24:131-143.

A-14 Feng, J.C.; Sidhu, S.S.; Feng, C.C. 1989. The rate of relase of surface-coated hexazinone from Pronone 10G granules under laboratory and field conditions. Can. J. For. Res. 19:378-381.

A-15 Feng, J.C.; Stornes, V.; Rogers, R. 1988. Release of hexazinone from PRONONE 10G granules exposed to simulated rainfall under laboratory conditions. J. Enviorn. Sci. Health B23(3):267-278.

A-16 Humburg, N.; Colby, S.; Hill, E.; Kitchen, L.; Lym, R.; McAvoy, W; Prasad, P. 1989. Herbicide Handbook, VI edition. Weed Sci. Soc. Am. Champaigne, Ill. USA. 513 pp.

A-17 Kreutzweiser, D.P.; Kingsbury, P.D.; Feng, J.C. 1989. Drift response of stream inverstebrates to aerial applications of glyphosate. Bull. Environ. Contam. Toxicol. 42:331-338.

A-18 Lanteigne, L.J. 1984. The impact of cleaning with herbicide on successional development and the growth of balsam fir after clearcutting a fir-spruce forest. M.Sc.F. Thesis. Univ. New Brunswick.

A-19 Payne, N.; Feng, J.; Reynolds, P. 1987. Off-target deposit measurements and buffers required around water for aerial glyphosate application. FPM-X-80. 37pp.

A-20 Prasad, R. 1988. Effects of nonylphenol adjuvants on macrophytes. In P.N. Chow et al. Ed. Adjuvants and Agrochemicals. Vol. I: 51-61. C.R.C. Press Inc. Fla. USA.

A-21 Prasad, R. 1989. Role of some adjuvants in enhancing the efficacy of herbicides on forest species. In P.N. Chow et al. Ed. Adjuvants for Agrochemicals. Vol. I 159-156. C.R.C. Publ. Inc. Fla. USA.

A-22 Prasad, R. 1989. Registration of forest nursery herbicides in Canada. Pesticides XXIII: 19-22.

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A-24 Richardson, J. 1979. Releasing softwood regeneration from overtopping alders. Inf. Rep. N-X-169. 24 pp.

A-25 Richardson, J. 1982. Release of young spruce and pine from alder competition. Inf. Rep. N-X-211. 13 pp.

A-26 Richardson, J. 1984. Control of hardwood competition and release of softwood regeneration on a mixedwood cutover in western Newfoundland. Inf. Rep. N-X-225. 23 pp.

A-27 Roberts, J.R.; Loud, P.M.; Stemeroff, M.; Stephenson, G.R.; Sutton, R.F.; Ales, C.R.; Edgington, Q.V.; Payandeh, B. Evaluation of the biological and economic benefits of pesticide use. Assoc. Comm. on Scientific Criteria for Environmental Quality. Nat. Cou. Canada. Publ. NRCC No. 23988. 293 pp.

A-28 Roy, D.N.; Konar, S.K.; Banerjee, S.; Thompson, D.G.; Prasad, R. 1989. Uptake and persistence of glyphosate (Vision) in fruits of wild berries. Can. J. For. Res. 19: 842-847.

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A-32 Sheedy, G. 1984. Mesures et observations de pin gris (Pinus banksiana Lamb.) en contenant et à racines nues, trois ans après la plantation. Min. de l'Energie et des Ressources, Serv. de la recherche forestière. Note no 21, 14 p.

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A-34 Stace-Smith, R. 1962. Studies on Rubus viruses in British Columbia. VIII. Raspberry leaf curl. Can. J. Bot. 40:651-657.

A-35 Sutton, R.F. 1986. Hexazinone Gridballs@ applied with concurrent underplanting of white spruce in boreal mixedwoods: 7-year results. For Chron. 62:226-232.

A-36 Templeton, G.E. 1982. Biological herbicides: discovery, development, deployment. Weed Sci. 30:430-433.

A-37 Wall, R.E. 1983. Fireblight of wild raspberry on clear-cut forest areas. Can. For. Serv. Res. Notes 3:2-3.

A-38 Wall, R.E. 1990. The fungus Chondrostereum purpureum as a silvicide to control stump sprouting in hardwoods. North. J. Appl. For. (in press).

A-39 Willis, R.; Fletcher, R.A.; Stephenson, G.R.; Prasad, R. 1989. Seasonal variations and crop tolerance of some conifer species to glyphosate and tricolpyr. Weed Technology 3:33-38.

A-40 Wood, J. E., 1983. Five-year Comparison of Jack Pine Bare-root, Ontario Tube, and Paperpot Seedlings. Serv. canadien des forêts, Centre de recherche forestière des Grands Lacs. Rapport d'inf. O-X-355. 17 p.

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B-2 Dorworth, C.E. 1989. Indigenous mycoherbicides for forest weed constraint. - The PFC Enhancement Process. Proc. Ann. Mtng. Prof. Pest. Mngt. Assoc. of B.C. Vancouver, B.C. Feb. 1989, (abst. - in press).

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B-5 Feng, J.C.; Thompson, D.G. 1989. Persistence and dissipation of glyphosate in foliage and soils of a Canadian coastal forest watershed. p. 65-87 In P.E. Reynolds, Ed. Proc. of Carnation Creek Herbicide Workshop. Nanaimo, B.C., 1987.

B-6 Feng, J.C.; Thompson, D.G.; Reynolds, P.E. 1989. Fate of glyphosate in a forest stream ecosystem. p. 45-64 In P.E. Reynolds, Ed. Proc. Carnation Creek Herbicide Workshop, Nanaimo, B.C., 1987.

B-7 Hatcher, R.J. 1984. Résultats préliminaires de plantations expérimentales de semis de conifères en conteneurs. Deuxième atelier de travail sur la culture des semis en récipients p. 115-129

B-8 Pitt, D.G., P.E. Reynolds and M.J. Roden. 1989. Crop tolerance and herbicide efficacy after site prep with liquid and dry-flowable hexazinone formulations. Proceedings of the Northeastern Weed Science Society, Supplement, Volume 43. In Press.

B-9 Prasad, R. 1983. Some physiological and phytotoxic effects of herbicides on forest seeds and seedlings. I. Evaluation of herbicidal properties by a seed germination technique. Proc. I.U.F.R.O. Symposium on Seed & Cones, p. 168-177.

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B-11 Prasad, R. 1986. Some aspects of the minor use program and registration of nursery herbicides in Canada. Proc. 2nd Canadian Tree Nursery Weed Control Symposium, p. 32-39.

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B-13 Prasad, R. 1988. Effects of adjuvant on foliar penetration and translocation of glyphosate-C14 in Betula papyrifera L. Ibid.: 187-188.

B-14 Prasad, R. 1989. Crop tolerance of three west coast conifer species to glyphosate. p.189-196. In P.E. Reynolds, Ed. Proc. Carnation Creek Glyphosate Workshop, Nanaimo, B.C. 1987.

B-15 Prasad, R.; Cadogan, B.L. 1988. Influence of small droplets on herbicide toxicity Proc. A.C.A.F.A. Symposium, Aerial Applications of Pesticides in Forestry, N.R.C.C No # 29197. AFA-TN-18. p. 309-319.

B-16 Prasad, R.; Feng, J. 1988. Red pine release and residue persistence after hexazinone spotgun treatment in northern Ontario. p. 107-115. In K.M.S. Sundaram, Comp., Proc of the XXth Annual Eastern Canada Workshop on Pesticide Residues and Environmental Contaminants. Sault Ste. Marie, Ontario.

B-17 Reynolds, P.E.; Pitt, D.G.; Roden, M.J. 1989. Crop tolerance after spring soil treatment with hexazinone, sulfometuron-methyl and metsulfuron-methyl. Proc. Northeastern Weed Science Society, Supplement, Volume 43. In Press.

B-18 Reynolds, P.E.; Pitt, D.G.; Roden, M.J. 1989. Herbicide efficacy and crop tolerance after fall soil treatment with liquid and granular hexazinone. Proc. Northeastern Weed Science Society, Supplement, Volume 43. In Press.

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B-21 Sundaram, K.M.S and R. Prasad. 1983. Research on forest herbicides in Canada: problems, progress and status. Proc. Herbicide Chemistry and Biochemistry Workshop, p. 42-52.

B-22 Thibault, M. 1987. Carte: Les régions écologiques du Québec méridional, deuxième approximation. Ministère de l'Energie et des Ressources, Québec. Bibliothèque nationale du Québec, 2e impression, 3e trimestre 1987.

C. Expert Committee on Weeds (ECW) Reports

C-1 Dorworth, C.E. 1987. Mycoherbicides in Forest Weed Control. Ann. Mtng. ECW - West. Sect.

C-2 Feng, J.C. 1988. Cross-wind effect on aerial application of granular hexazinone. ECW - West. Sect., Res. Rep. 3:203.

C-3 Feng, J.; Campbell, R. 1985. New methods for soil sampling and residue reporting in a study on persistence of Velpar-L in boreal forest soils. ECW - East. Sect., Res. Rep. 3:593.

C-4 Feng, J.C.; Feng, C.C. 1988. Persistence of hexazinone in Alberta soils. ECW - West. Sect., Res. Rep. 3:182.

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C-6 Geier, R.L.; Feng, J.C.; Campbell, R.A. 1986. Biological significance of hexazinone residues in a boreal forest soil ECW - East. Sect., Res. Rep. 3:715.

C-7 Lanteigne, L.J.; Burns, T.W.; Hallett, R.D. 1985. Effects of pre-emergence herbicides on weed control and the growth of r1 + 0 black spruce and jack pine seedlings. ECW - East. Sect.

C-8 Lanteigne, L.J.; Burns, T.W.; Hallett, R.D. 1985. Effects of sethoxydim, fluazifop-butyl, and oxyfluorfen on weed control and black spruce container seedlings. ECW - East. Sect.

C-9 Lanteigne, L.J.; Burns, T.W.; Hallett, R.D. 1986. Effects of various pre-emergence herbicides on germination and growth of jack pine seedlings within a bareroot seedbed. ECW - East. Sect.

C-10 Lanteigne, L.J.; Burns, T.W.; Hallett, R.D. 1986. Effects of various pre-emergence herbicides on germination and growth of black spruce seedlings within a bareroot seedbed. ECW - East. Sect.

C-11 Lanteigne, L.J.; Burns, T.W.; Hallett, R.D. 1986. Effect of sethoxydim, fluazifop-butyl, and oxyfluorfen on control of rye grass. ECW - East. Sect.

C-12 Lanteigne, L.J.; Burns, T.W.; Hallett, R.D. 1986. Effect of napropamide and oxyfluorfen on the growth of black spruce bareroot seedlings. ECW - East. Sect.

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Appendix C. Contributing Authors and Current Affiliations

This list is provided to assist contacting authors for additional information if required. Forestry Canada regional office addresses, telephone numbers, and fax numbers are listed in Appendix D. Contact with authors outside of Forestry Canada can be achieved through the Forestry Canada co-author.

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Appendix E. Guidelines for Submission of Summaries

In an effort to summarize current vegetation management research in Canada, the Forestry Canada Vegetation Management Working Group would like to have summaries of the studies and projects related to vegetation management conducted by all agencies within Canada. The primary objectives of this excercise are to collate the vegetation management work being done, to make the information available, to assimilate the data into operational programs, to expose aspects of vegetation management that need further work, to maximize the efficiency of vegetation management research, and to avoid undue duplication of effort. We therefore request all agencies and personnel involved with research pertaining to vegetation management to provide summaries of their work to the Vegetation Management Working Group member (see Appendix D for addresses) in the appropriate region through the use of the following outline:

Each study (or project) should be summarized separately. Summary length is limited to 55 lines of text, double-spaced, on 8.5 × 11-inch pages with 1-inch margins. Please use wrap-around procedure rather than carriage returns, and use tabs for tables. Submit a WordPerfect 5.0 disk. Text should be prepared in the following order:

1.	**Author(s):**	Investigator(s) with initials, last name followed by initials in all cases, and a semicolon to separate multiple authors.
2.	**Title:**	Boldface, upper and lower case, not italics.
3.	**Objectives:**	Brief, one sentence.
4.	**Location:**	Closest city and province, forest mangement region/unit, elevation, and other appropriate designators.
5.	**Methods:**	*Site History* — Previous stand (composition, age, height, etc.); harvest (method, time, year); site preparation (method, time, year); time and type of treatment; planting (time, year, stock type, species, physiological status at the time of treatment, initial density, height, etc.) *Soils* — Texture, type, OM content, duff thickness, moisture regime. *Application Specifications* — Type of mechanical equipment used (time, year, moisture conditions, size of mound or scrape); type of brush saw; burning (degree, time, year); application equipment (type, speed, height, swath width); type of boom (leading or trailing edge); nozzle (number, type, size, orientation); boom pressure; herbicide (type, application rates, carrier, adjuvants, total volume); weather before, during, and after treatment. *Experimental Design* — Plot size, number of replications, number of observations, etc. *Measurements Taken* — Date; species (crop and those being controlled); height; diameter; etc.
6.	**Results:**	If results are available, one short table may be used if appropriate.
7.	**Conclusions:**	If available.
8.	**Contributing agency:**	Place in parentheses, upper and lower case, boldface, after text.

Note: Use common names for all plant species, but supply the scientific name and authority for each species on an attachment (this is not necessary if both the common and scientific names with authority are already in this report). If no common names exist for the species, such as is commonly the case with fungi, bacteria, etc., then use the scientific name with authority given the first time the name is used. Use common names for all chemical products where possible and provide the manufacturers if you use trade names. A list of manufacturers will appear as an appendix. The words "title," "author," and "contributing agency" are not spelled out in the summary; the words "Objectives," "Location," "Methods," "Results," and "Conclusions" are in boldface type (highlighted); the words "Site History," "Soils," "Application Specifications," "Experimental Design," and "Measurements Taken" are underlined and will appear italics. Please use the summaries in this report as examples.

Please submit the completed summaries to the Forestry Canada representative in your province, or to the chairperson of the working group. Use electronic mail where possible or submit the summaries on a floppy disk using an IBM formatted disk and compatible software. Please use WordPerfect 5.0 if available. If you already have an accessible computer storage and retrieval system, perhaps we can make arrangements to access it; please contact the working group member for further details if required. If you want to revise a text already published, please contact Scientific Publications for a disk or an electronic text to work with.